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Houses and Equipment

FOR LAYING HENS

. . . for loose housing

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

CONTENTS

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Houses and Equipment

FOR LAYING HENS... for loose housing

By Hajime Ota, *agricultural engineer, Agricultural Engineering Research Division, Agricultural Research Service*

METHODS OF HOUSING

The right kind of a house for laying hens is extremely important to the poultryman. It facilitates good production of quality eggs, results in economy of feed, and helps insure freedom from disease. It accomplishes this by providing light, dry, clean, well-ventilated quarters for the hens and by protecting the hens from wind, rain, and snow, as well as from sudden changes in temperature and from excessive dust and ammonia gas.

The interior of a laying house should be so arranged and equipped that both the hens and the eggs can be cared for with a minimum of labor and time. Construction and upkeep costs should be reasonable, and the house should be neat.

Two methods are widely used to house laying hens. The first is to house them in wire cages. The second is to use loose housing. This bulletin deals principally with this second method.

The cage method of housing laying hens is used throughout the country. Wire cages up to 12 inches wide may hold one, two, or three hens, depending on the size of the hens (fig. 1). Wire enclosures more than 12 inches wide with capacity of from 3 to 100 hens are known as colony or wire pens (fig. 2). Advantages of cages include:

- Lower feed costs.
- Better control over parasites and diseases.
- More uniform egg production.
- Less competition for feed and water.

When loose housing is used, the hens are kept in a building in which they are free to wander about. The floor is covered with litter or the hens are on wood-slat platforms raised about 16 to 18 inches above the floor (fig. 3). Also, a variation of management is to place poultry feeders and waterers above a partial wood-slat floor with a mechanically cleaned pit under it and a litter floor on either side of the pit. Eggs are conveyed from the individual nests on an endless belt and collected at a central point and stored in a refrigerated egg-cooling room (cabinet). Feed is delivered to two large bulk-feed bins outside the house. Prefabricated adjustable ridge vents and fans are mounted on the sidewalls of the building.

Tiered roosts with mechanical feeders and waterers may also be used above a mechanically cleaned pit; floors along both sides of the pit are covered with litter (fig. 4). This house is equipped with foggers above the roosts for emergency cooling in summer. With feeders and waterers above a mechanically cleaned pit, about 75 percent of the poultry fecal matter falls into the pit. The advantages of a house with an all-litter floor or a partial-litter floor include:

- Less odor outside of the house.
- Less fly-control difficulty.
- No wire floors that cause water to condense during foggy weather and wire mark the eggs.

Investment in laying housing depends largely on the bird population in a house. Hens are housed in cages with densities as low as 0.3 square foot per hen. In loose housing, densities of 1 to 1½ square feet per hen are common in houses using a combination of slatted floor and litter floor, on an all-slatted floor, or on a litter floor with poultry equipment on tiered roosts. In general, if hens are crowded in a loose housing system, cannibalism may become a serious problem.

TESTING EFFECTS OF HOUSING AND FLOCK SIZES

The important effects of good housing on production and feed consumption was shown by a series of 3- to 6-week tests at different constant air temperatures, conducted by the U.S. Agricultural Research Service, Beltsville, Md. Ten locally hatched Rhode Island Red hens, in their first year of production, were kept on litter in each test. Air temperature, relative humidity, ventilation rate,

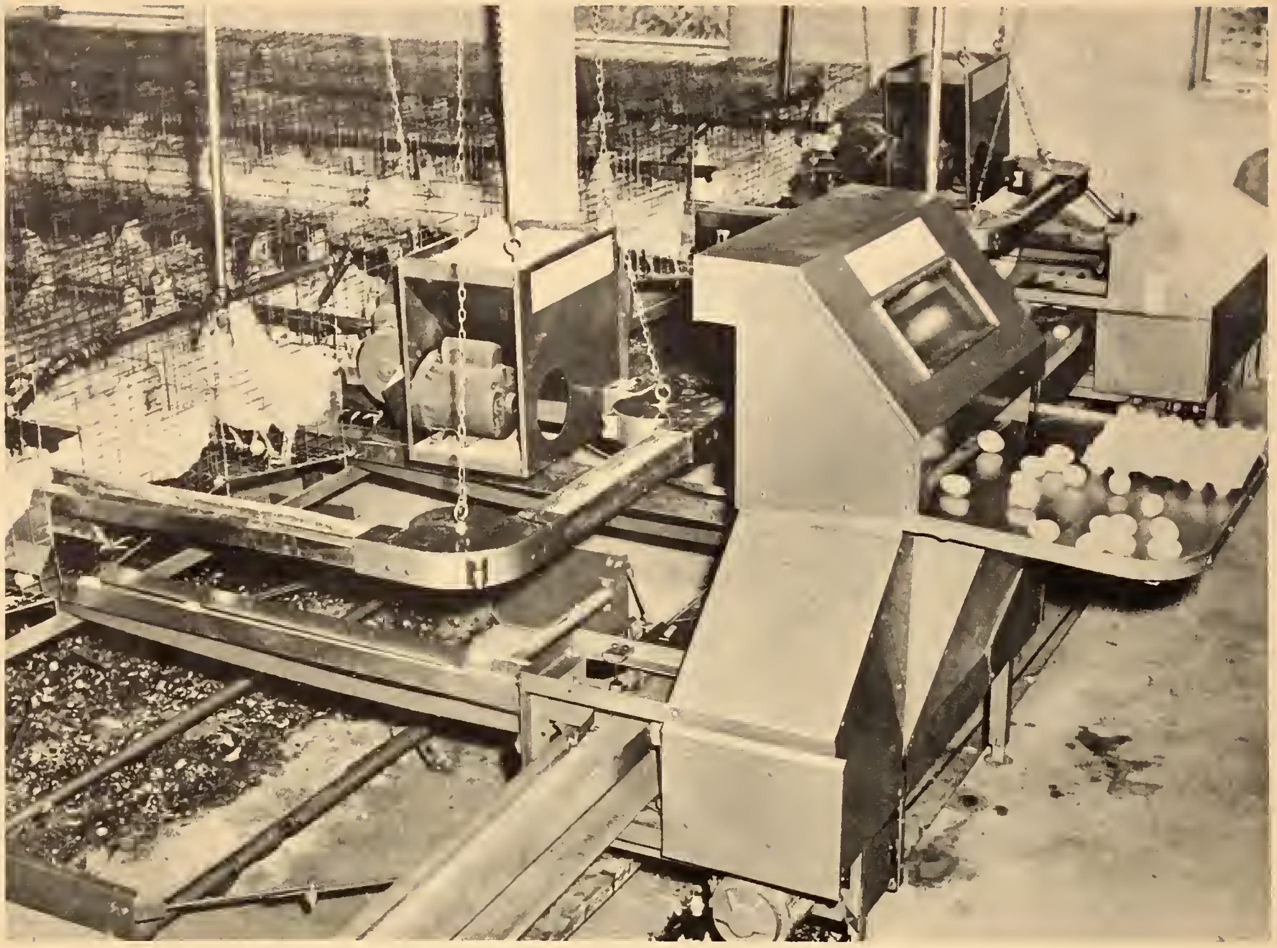

FIGURE 1.—Automated wire-cage laying house with mechanical feeders, waterers, egg collector, and pit cleaner.

lighted hours, water, and litter management were controlled.

The investigation showed that as egg production fell off at low temperature, weight per egg increased slightly. Small eggs with poor shells were laid at temperatures above 80° to 85° F. The least weight of feed per pound of eggs was required at temperatures between 45° and 75°. The feed requirement at 37° was 21 percent more than at 55°.

The results also showed that protecting the hens from low temperatures saves feed, whereas protecting them from high temperatures results in higher rate of egg production. The laying hens produced well at air temperatures between 45° and 85° F. At higher temperatures, the humidity should be kept below 75 percent if possible.

To decrease the effects of air movement (draft) in winter, hens in houses having open sidewalls must be protected. Too much air movement near the birds gives them the sensation of being at a low temperature.

Figure 5 shows the approximate feed consumption of various size laying hens at different rates of egg production. Below 40° F., feed consumption may increase as much as 10 to 15 percent above the values shown in the figure. Above 85°, feed consumption may decrease to as little as one-half below the values shown in the figure. However, over a period of time, the amount of feed not consumed in 1 hot day may be consumed later during cool days.

For design purposes, the data should be used as shown for feed storage space, and the feeding rate should be selected at the 75 percent egg-production level.

Studies by the U.S. Department of Agriculture in cooperation with the University of Illinois show that annual chore time for efficient producers with automatic equipment is 30 to 40 man-hours per 100 layers. The U.S. average annual chore time (1959) is 162 man-hours per 100 layers for flocks of fewer than 400 chickens, and 103 man-hours for larger flocks. The overall average annual

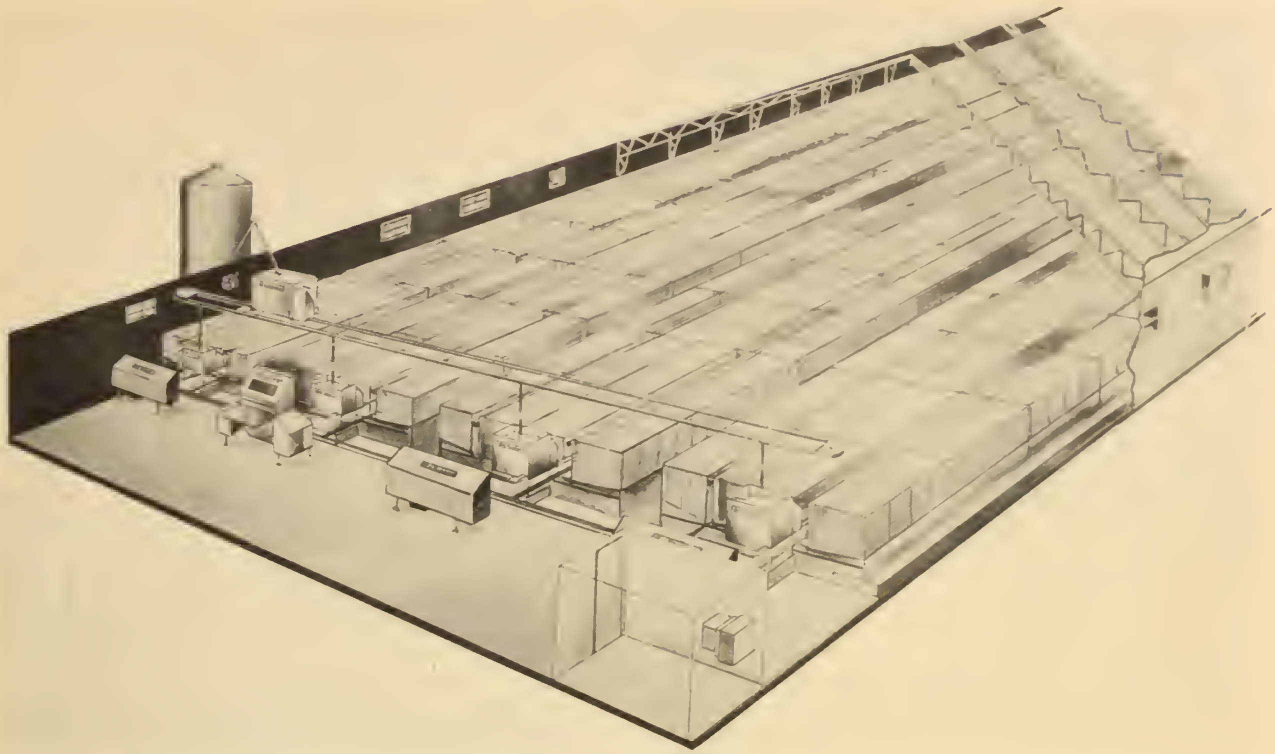

FIGURE 2.—Automated laying house with wire pens or colony cages and with mechanical feeders, waterers, egg collector, pit cleaner, and egg-cooling room.

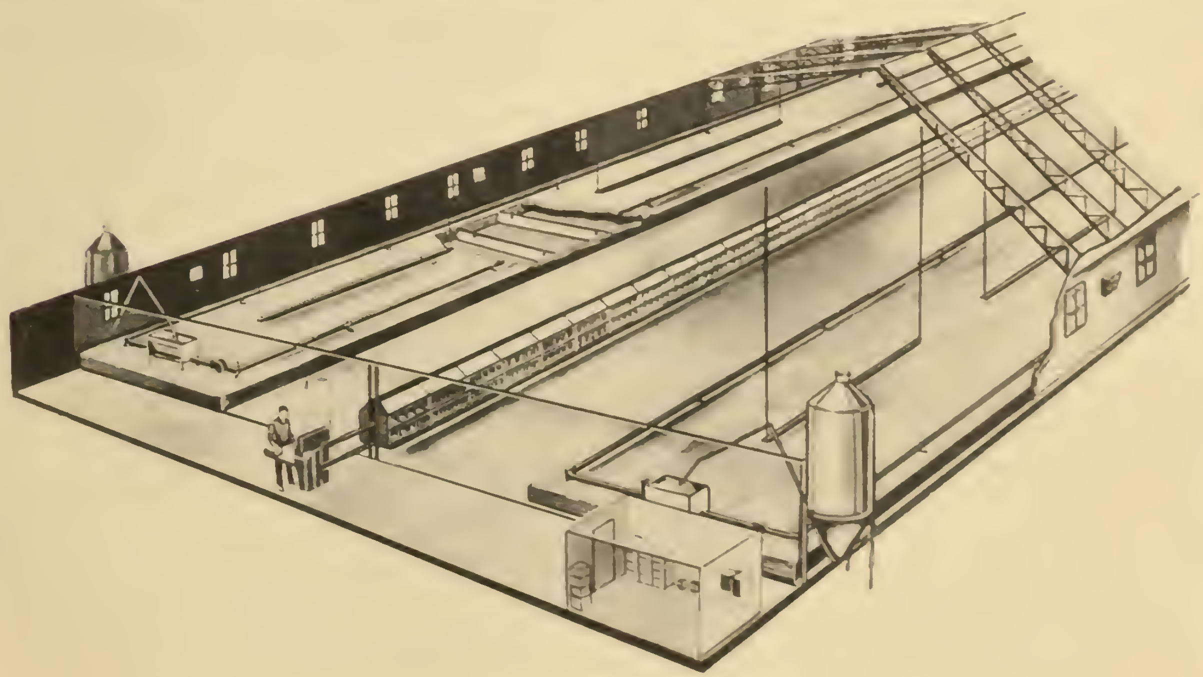

FIGURE 3.—Automated laying house with mechanical feeders and waterers above a raised platform and with partial wood-slat floors.

FIGURE 4.—Automated laying house with mechanical feeders and waterers on tiered roosts.

chore time per 100 eggs produced is 0.73 man-hour, or 44 minutes per 100 eggs.

Other State and Federal studies have shown that the time spent, as well as the distance walked, can be reduced with large flocks, improved housing, efficient layout, and mechanization.

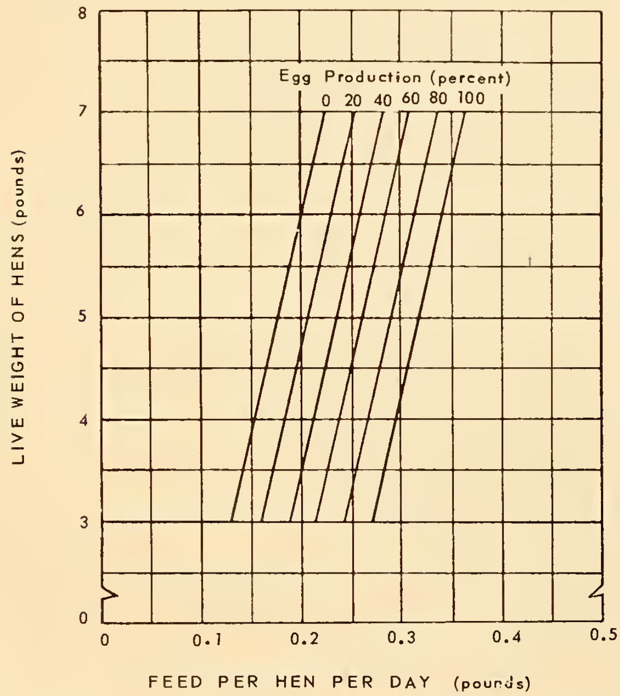

FIGURE 5.—Approximate feed consumption of various size laying hens at different rates of egg production.

INFLUENCE OF CLIMATE ON LAYING-HOUSE DESIGN

Differences in climate account for much of the variation in types of laying houses used in the different States. A poultryman considering a new type of house should compare his own climate with that where such a house has been used successfully.

Temperature, sunshine, wind, and relative humidity are probably the most important climatic factors to consider in determining the structural design of the house.

A farm building-zone map, based on January temperatures and relative humidity, is shown in figure 6. The number of hours per day of winter sunshine are shown in figure 7.

The average January temperature in zone 1 is below 20° F.; in zone 2, 20° to 35°; in zone 3, 35° to 50°; and in zone 4, above 50°. Minimum temperatures seldom fall below freezing in zone 4, but they often fall below −30° in colder parts of

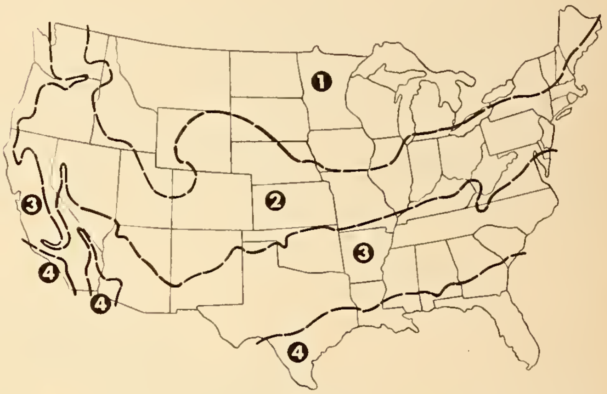

FIGURE 6.—Farm building-zone map, based on January temperatures and relative humidity.

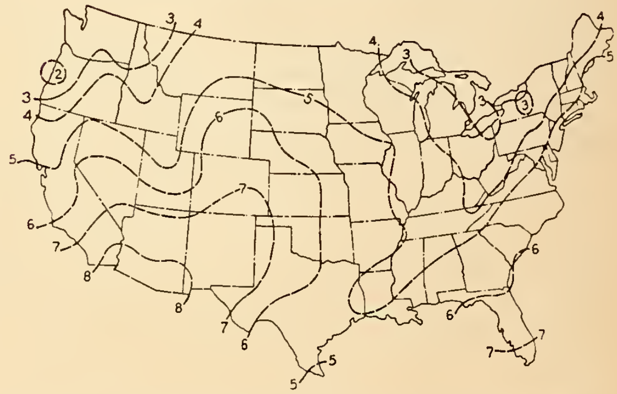

FIGURE 7.—Average number of hours of sunshine daily in December, January, and February.

zone 1. Summer temperatures are much more uniform throughout the Nation than are winter temperatures, the July average ranging from below 75° in zone 1 to above 80° in zone 4. Maximum temperatures are above 100° in all zones.

Sudden temperature changes may cause serious slumps in egg production. Exposure to hot sunshine or to high air temperatures and radiation from hot roof surfaces, especially when the relative humidity is high, may cause hens to die from heat prostration. Laying houses should therefore be designed to provide both winter and summer weather protection for all farm building zones.

FOUR TYPES OF LAYING HOUSES

Type 1.—Houses with no walls or with wire walls (fig. 8) are used in very warm climates. The house shown in figure 8 faces south. Little sunshine enters in summer, but considerable enters in winter. The sunshade on the west may be lowered in cool, windy weather and in the late afternoon summer sunshine to protect the hens.

FIGURE 8.—Wire-walled laying house in Arizona.

FIGURE 9.—Poultryman adjusting window curtain on open-front laying house.

The front, rear, and sometimes the end walls of these houses are of wire netting. Lightweight, plastic-covered panels may be used to partly close the house in winter, or the walls exposed to winter winds may be covered with reinforced paper. Wire walls may also be covered with adjustable plastic curtains. Generally, there is no wet-litter problem in these houses except during cold or damp weather.

Type 2.—The uninsulated building with large front-wall openings (figs. 9 and 10) is generally recommended by State agricultural colleges for flocks of all sizes in zones 3 and 4 and to some extent in zones 1 and 2. This type of building often has windows or curtains that can be closed during storms or cold weather. Under most conditions, open-front houses keep the litter dry and the eggs clean; but egg production may fall off seriously and unprotected water fountains and eggs may freeze in cold weather.

Type 3.—The warmly built house with insulated walls and ceiling and controlled ventilation is recommended by most State agricultural colleges for zone 1. It is also used for most large flocks in zones 2 and 3, and may be either one story or multistory (fig. 11). Some houses of this type have large windows of insulating glass to trap more winter sunshine (fig. 12). The house in figure 12 is used successfully as far south as Georgia, in farm building zone 3. Overhanging roofs keep out the sun in summer. Manufacturers of insulating glass can supply information on the overhanging roof required to suit the specific location.

A warm house in winter and a cool one in summer is the straw-loft house with insulated walls and a layer of 10 to 14 inches of straw in the ceiling. Because it is difficult to sanitize the straw

FIGURE 10.—Open-front laying house at the U.S. Agricultural Research Center, Beltsville, Md.

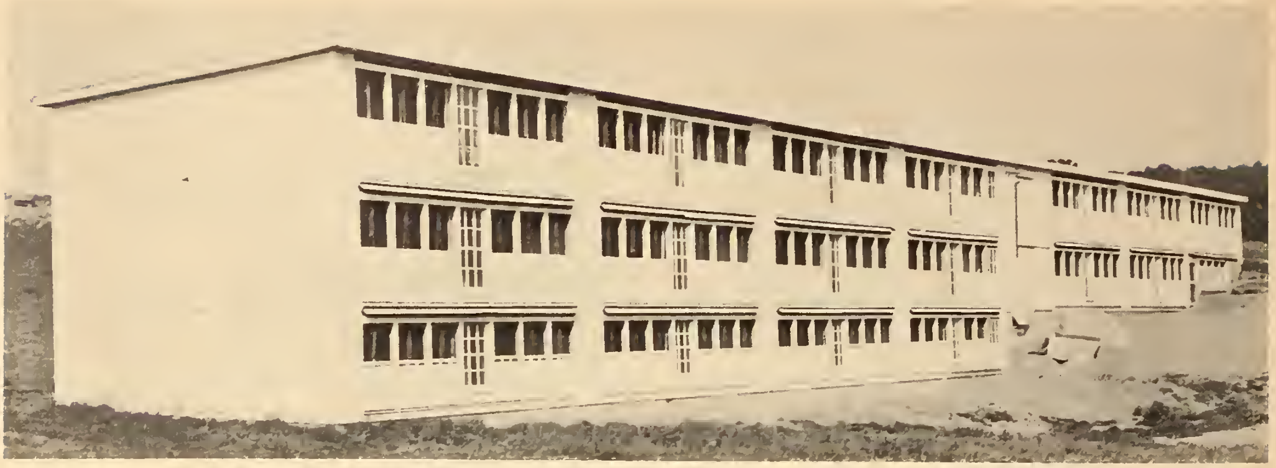

FIGURE 11.—Multistory laying house on hillside in Connecticut.

FIGURE 12.—Solar laying house showing large insulating glass windows with sunshade designed to shade windows in summer but not in winter.

ceiling, in the event of a disease outbreak, this type of housing is not recommended for large flocks.

Type 4.—Insulated windowless laying houses of lumber, hardboard, metal, or plywood are used in zones 1, 2, and 3 (fig. 13). At the gable end in the foreground of the house shown here are the egg-cooling machine and a small door for removing cased eggs from egg-cooling rooms. Controlled lighting and mechanical ventilation are needed in these houses. In dry areas of zones 2, 3, and 4, packaged window-type (fig. 14) or fan and pad-type (fig. 15) evaporative coolers are used with this type of house. For laying houses up to 200 feet long, the cooling unit is on one end wall and the exhaust fans are on the other. In larger houses, the cooling unit is on one sidewall and the fans are on the opposite wall. The air velocity through a 2- to 3-inch pad should be 150 feet per minute.

Prefabricated laying houses of various sizes are available, complete with all poultry equipment.

SPECIAL PROBLEMS OF THE SMALL FLOCK

In northern parts of the United States, the small flock of fewer than 400 hens presents a special housing problem. More than half the flocks are this small size. None of the four types of houses described, if fully exposed to the weather, is entirely satisfactory for so few hens because the heat given off from their bodies is not enough to warm a house in cold weather. On the other hand, flocks of fewer than 400 hens do not lay enough eggs to justify the expense of installing extra-heavy insulation or a heater in an exposed house.

FIGURE 13.—Insulated windowless A-frame laying house with fans on the sidewall, prefabricated ridge vents, and bulk-feed storage bin. In foreground at gable end is egg-cooling machine and door for removing cased eggs from egg-cooling room.

FIGURE 14.—Windowless laying house in southern California with packaged window-type evaporative coolers in sidewalls.

One way to provide good conditions for the small flock in a cold climate is to keep them in a well-insulated room of a larger building. Another way, where a dry south slope is available, is to set the house in the hillside for protection. The floors and the walls in contact with the bank should be waterproofed, and aboveground walls and the roof should be insulated.

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SPECIAL PROBLEMS OF THE LARGE FLOCK

Hens in large flocks are usually confined in the house at all times. The trend is toward houses 30 to 40 feet wide, although some houses may be as much as 60 feet wide for large flocks. Wide houses are cheaper to build and are generally more

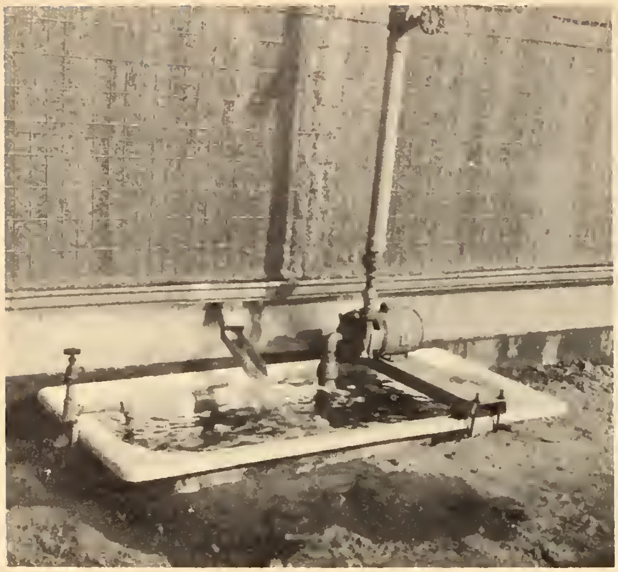


FIGURE 15.—Windowless laying house in southern California with an excelsior hay pad and accessories used in a fan and pad-type evaporative cooler.

TABLE 1.—*Floor area for laying hens on all-litter floor*

Breed size	Hens in pen	Floor area per hen [1]
	Number	*Square feet*
Small	25	4
	100	3½
	200	3
	400	2¾
	600–1,000	2½
Large	25	4½
	100	4
	200	3½
	400	3¼
	600–1,000	3

[1] In hot weather, allow an additional ½ square foot per hen.

comfortable for the hens in the winter than long, narrow houses with the same floor area; but if they are too wide, they may be hard to light and ventilate. Large drive-in doors built in the end walls are convenient at house-cleaning time, and they allow more air to circulate during summer. Wide houses are better suited than narrow ones for using litter stirrers, tractor scrapers, mechanized feeders, and other labor savers.

Multistory houses (fig. 11) are warmer in winter and may be cheaper to build than large, one-story houses having the same floor area. Multistory houses are popular in regions where level sites are hard to find. Moving feed, eggs, and litter to and from upper floors is difficult in this type of house. A power-operated feed elevator or a bulk-feed truck may be used to deliver feed to the upper stories. On a hillside, a ramp may be built to the upper levels.

SPACE REQUIREMENTS

The general trend is to limit the size of flock per pen to about 500 to 1,000 hens. General recommendations for floor area for laying houses without pits or slatted floors are shown in table 1. An additional half square foot per hen is needed when hens are confined in hot weather.

In some houses tiers of feeders and waterers are placed above the droppings pit. A mechanical pit cleaner may be used to clean the pit frequently; this reduces the amount of evaporated moisture to be removed by the ventilating system. With this arrangement, some poultrymen allow only ¾ to 1¼ square feet per hen. About 75 percent of the droppings falls into the pit.

SUMMER COMFORT

In hot weather, good air circulation through the house is essential for the comfort of the hens. Shade from trees, light-colored (or reflective) roofing, and roof insulation help protect the hens against extreme heat. In building zones 3 and 4, continuous ridge ventilators, floor-level windows, and large end doors are also desirable (fig. 16).

Areas of wall openings suggested for uninsulated, partly insulated, and well-insulated laying houses vary in the four zones. The areas of openings indicated (table 2) are compromises between provision for free air movement in summer and protection against cold in winter. The areas are calculated as percentages of the floor area. For example, in a 20- by 20-foot house, if an opening equivalent to 10 percent of the floor area is desired, the area of the opening would be 40 square feet.

To provide other aids to summer comfort:

- Apply whitewash or white paint on galvanized sheet metal; apply whitewash on dark-colored roofing. For detailed information on whitewashing, see the section, "Roof Covering," page 19.
- Cover the roofs of small houses with straw, weeds, or other vegetation.
- Double the watering space, and run water continually so that hens always have fresh, cool water.
- When the outdoor air temperature is above 85° F., place fans in the house to increase air movement by drawing air from the cool side of the house. Never circulate air from one pen to the next.

FIGURE 16.—A 24- by 160-foot laying house with reflective roofing, continuous ridge ventilators, floor-level windows, and large end doors.

TABLE 2.—*Minimum area of wall openings* [1] *for summer ventilation, stated as a percentage of the floor area*

Type of house	Combined front and side walls				Rear walls			
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Open front	(2)	10–15	12–20	18–30	(2)	1–4	6–10	8–20
Straw loft [3]	6–9	8–12	10–15	(2)	0–2	1–3	4–6	(2)
Well insulated	4–6	6–10	(4)	(4)	0–1	1–2	(4)	(4)

[1] Not including area of entrance doors.
[2] Type not recommended for this zone.
[3] Includes straw-loft house with walls insulated.
[4] Type not recommended without fan ventilation or evaporative coolers.

Excessive ventilation with fans will hasten the rise in house temperature to equal that outdoors during the hottest period of the day. Ventilate at maximum rate during the night preceding a hot spell to store "cooling effect" in the building and then ventilate at low rate during the day. The low rate of ventilation may be near 3 cubic feet per minute (c.f.m.) per hen or less, depending on building materials, the amount of insulation, and bird density used. When the indoor air temperature has reached 85° F. and the percent relative humidity is 70, use maximum ventilation rates.

Use fog nozzles (fine-spray) inside the house to wet the hens. In humid areas this method should be used with caution. Avoid moistening the litter, as fermentation will heat the house.

Use evaporative coolers, packaged or the fan and pad types, in all building zones where relative humidity does not exceed 65 to 70 percent from noon to about 7 p.m. in summer.

Install sprinklers or porous hose on the roof.

In an emergency, drive the birds out of the house into woods or other cool, shady areas.

Set blocks of ice in the house and blow air against them with an electric fan.

To keep out summer sun from houses facing south, use sunshades or an adequately wide roof overhang.

WINTER COMFORT

Laying houses are ventilated in winter to remove excess moisture, odors, and airborne disease organisms, and to maintain dry litter for clean-egg production. The aim is to keep the relative humidity of the house air below 80 percent and the litter moisture content below 40 percent. Temperature control in the house depends on construction, insulation, ventilation rate, and floor area per hen.

In building zones 3 and 4 and in the warmer, sunnier parts of zone 2, uninsulated open-front construction is considered satisfactory by most producers. Drop curtains or shutters may be used to partly close the front for protection during exceptionally cold weather, but no special ventilation is needed for this type of house. The house may become quite damp when closed during cold weather, but it will dry out rapidly on warm, sunny days when the front is open.

Commercial egg producers in building zone 3 insulate both wire cage houses and those with all-litter or partial-litter floors. The approximate amount of insulation ranges from an equivalent of 1 to 2 inches of glass wool in the walls to twice this in the ceiling or in spaces between the rafters.

In zone 1 and in the colder parts of zone 2, well-insulted or straw-loft houses are needed if the house temperature is to be kept above freezing during cold weather. Skilled ventilation control is needed at that time to keep the house and litter dry.

Tests conducted with hens on litter by the U.S. Agricultural Research Service, Beltsville, Md., showed that to avoid wet litter, an average of one-half to two-thirds pint of water per hen per day must be removed by ventilation. Part of this moisture is given off in the hens' breath; the rest evaporates from droppings and from water spilled fom drinking fountains.

The heat produced by the hens, plus that gained from sunshine and from fermentation of the litter, is not enough to maintain adequate warmth in the uninsulated house on cold days. Consequently, during colder-than-average weather, the moisture content of the litter may build up to the "wet-litter" stage. The smaller the house, the harder it is to keep it dry in cold weather.

To keep the litter dry:

- Insulate the house well; this includes using storm windows or insulating-glass windows in the coldest climate and keeping the glass clean to let in sunlight.
- Use waterers that do not overflow and that are designed to prevent excessive water waste by the hens. A suitable wire-covered platform and drain will help to dispose of waste water. Minimum drain-tile size should be 6 inches, with a slope of 12 inches per 100 feet to an outlet. Some poultrymen connect a downspout from the roof to flush this drain.
- Do not overcrowd the house.
- Use a type of litter that does not pack readily and that hens like to scratch in. Keep litter depth at least 6 to 8 inches. Stir litter from time to time.
- Remove wet litter around water fountain frequently and replace with dry.
- Frequently clean droppings boards and droppings pits in houses equipped with mechanical cleaners. Thus, much of the water in the droppings is removed before it evaporates.
- Place waterers and feeders over the pit in houses with mechanical cleaners.
- Air the house on warm days and during warm, sunny hours. Supply additional heat to the house during cold or damp weather.
- Observe areas that the hens do not occupy. These areas are too cold. Remedy this situation by sealing up nearby holes and cracks in the doors or windows.

SYSTEMS OF VENTILATION

Two types of ventilation are commonly used—the gravity, or natural, system and the fan-operated system. Methods of obtaining draft-free gravity ventilation are shown in figures 17 and 18. The gravity system depends on cold outdoor air to force the warmer, lighter air out

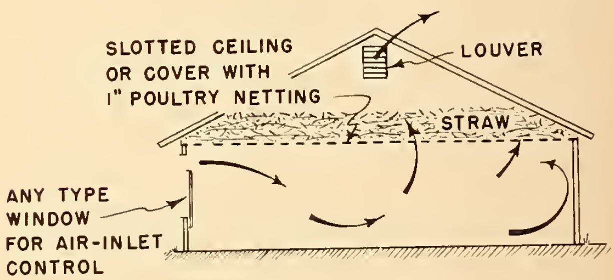


FIGURE 17.—Gravity ventilation of a small straw-loft laying house.

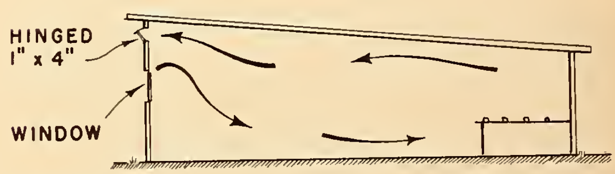


FIGURE 18.—Gravity ventilation of a fully insulated laying house.

of the house. This worked well in the old straw-loft house (fig. 17), with fresh air entering through windows opened 1 or 2 inches at the top, or through continuous narrow slots under the overhanging roof on the south side, or through special inlets. The exhaust air passes out through the straw and through louvers in the gable ends of the house. Because of disease hazards, this system is not recommended for a large house.

The gravity system is used in insulated houses by providing ducts or ventilator heads for the escape of the exhaust air. In cold areas, flues must extend well above the roof ridge, and they must be insulated. If the air inlets or windows are well distributed and easily adjusted as the weather changes, this system works well. However, considerable time may be required to adjust these air inlets or windows.

In a modification of this system, one or more small electric motors, each controlled by a thermostat, are used to adjust the inlets and the exhaust ducts.

In closed, well-insulated houses (not open-front or straw-loft), more positive control of ventilation can be obtained with a fan system. The fan or fans should supply at least 4 c.f.m. of air per hen at 1/8-inch static pressure. For a house with 250 hens, fan capacity should be 1,000 c.f.m.

To dry out the house after a cold spell and to prevent too much temperature rise on warm days, 4 c.f.m. per hen is desirable. Because this volume is much too high for cold days, there must be a damper to adjust the rate of airflow. In addition, the poultryman should (1) use a thermostat to shut off the fan when the temperature drops below 35° F.; (2) use two fans in a large pen—a small one to run continually and a large one controlled by the thermostat (the small fan should have about one-third the capacity of the large one); or (3) use a two-speed fan having thermostat control, operated at low speed on cold days and at high speed on warmer days.

Wall fans are cheaper and easier to install than ceiling fans. A wall-type exhaust fan, set in a duct arranged to draw air from near the floor in cold weather and from near the ceiling on warm days, is shown in figure 19. A damper regulates the airflow. When both a large and small fan are used in the same room, they should be side by side.

For a house up to 60 feet long, the fan may be located at the end of the house, away from prevailing winds. In a longer house, fans may be located at the middle of the north wall of the house, immediately under the plate, and hooded against north winds. This arrangement draws fresh air through baffled openings on the warm side of the house across its entire width, and exhausts the foul air on the cold side. In summer, the fan is reversed to draw in cool, north-side air and to force heated air out the south side. One fan or a pair of fans should be in each room that is enclosed by solid partitions. In gable-roofed houses over 40 feet wide, an exhaust fan may be located in the ceiling under the ridge of the roof to force the air out through a vertical duct.

The pressure-type (or blow-in) system of ventilation has been sucessfully used in insulated houses with tight ceilings (fig. 20). Air drawn from the attic is warmed by sunshine on the roof and by heat leaking through the ceiling. The fan blades should be below the ceiling. The baffle under the fan is important to prevent drafts inside the house. Air leaves the house through narrow slots above or below the windows. The fan should run continually or should have self-closing louvers to prevent moisture condensation in the attic space caused by back drafting when controlled fans are not running.

The pressure-type ventilation system prevents drafts around doors and windows of poultry houses and forcefully mixes cold air with warm air in the house.

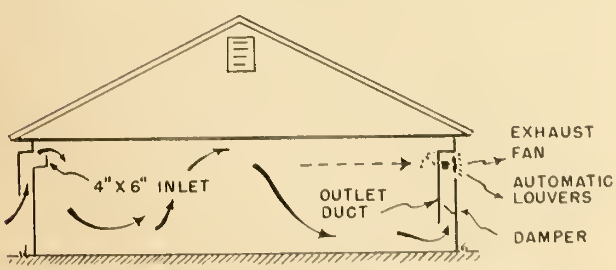


FIGURE 19.—Ventilation with a wall-type exhaust fan and duct.

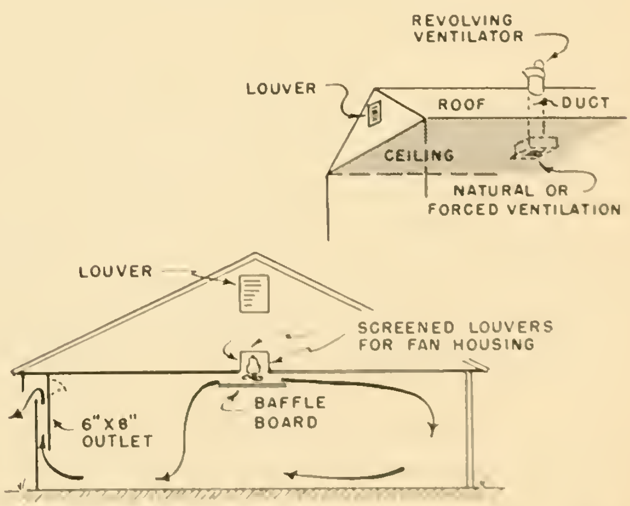


FIGURE 20.—Fan blowing air from attic into laying house in winter. *Upper right,* alternative arrangement, with fan mounted in ventilation stack or duct.

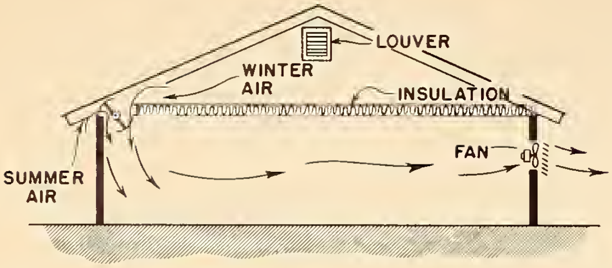


FIGURE 21.—Fan on sidewall drawing air from attic in winter. In summer, attic space is closed and outdoor air is brought into house through slot opening at eave.

Figure 21 shows another arrangement of pressure-type ventilation, in which fans are located along one sidewall. In winter the solar-heated air from the attic or under the roof is brought in from the opposite sidewall through 1-inch-wide slot openings at the plate. In summer the outdoor air is brought in through slot openings at the eave, and the attic space is closed off with a damper.

In winter, a static pressure of 0.01- to 0.02-inch water gage should be maintained to prevent back drafting of house air into the attic space in houses shown in figures 20 and 21.

A house without a ceiling may be ventilated as shown in figure 22. In summer, air is brought into the house through fans along one sidewall, and the air is exhausted through adjustable ridge vents on the roof and openings along the opposite sidewall (pressure-type system). In winter the fans are reversed and the air is brought into the house through the adjustable openings along the sidewall and ridge vents and is exhausted through the fans (blow-out system). Ridge vents are adjusted to limit the ventilation rate during cold weather. This system has proved to be drafty in cold weather because intakes drag air to the floor where it chills the hens. However, a circulating fan every 50 feet mixes cold air with room air and helps eliminate the drafts.

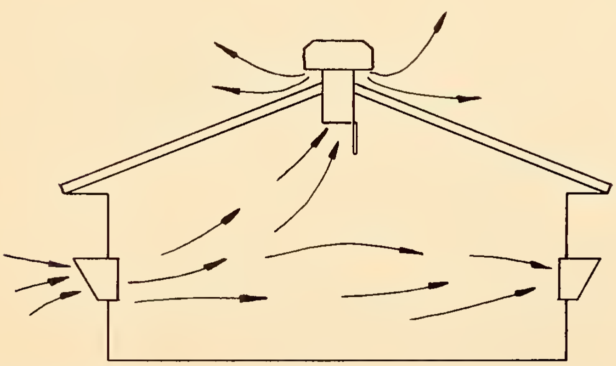


FIGURE 22.—In summer, outdoor air is drawn through a fan into the laying house and is exhausted through adjustable ridge vents and sidewall openings (blow-in system). In winter, the fan is reversed and air is drawn through ridge vents and sidewall openings and exhausted through the fan (blow-out system).

Fan motors should be totally enclosed to keep out dust. They should also be equipped with thermal-overload circuit breakers to prevent fire from starting in the motors if the fan becomes frozen or stalled. Fans should be the nonoverloading type to prevent motors from burning out if louvers blow shut or fail to open. The fan-motor housing and the blades should be kept free of dust and feathers. They should be screened with 1-inch poultry netting to protect chickens and human hands from the propeller blades.

Use only the fan manufacturer's recommended fan blades for a particular orifice or fan-blade housing. **Under no circumstance should fan blades be larger than the orifices.** Round orifice fan-blade housing is more efficient than square.

Operational cost and efficiency of fans may be gaged by dividing c.f.m. at 1/8-inch static pressure by watts of electrical energy to operate the fan. For example,

1/3-hp. fan motor
c.f.m. rating 4,000 at 1/8-inch static pressure
1/3 hp. $\times$1,000=333 watts
4,000$\div$333=12 c.f.m. per watt.

The inlets should distribute air evenly throughout the house. A continuous slot, 1 inch wide by 12 feet long, or the equivalent, will supply sufficient inlet air for 100 hens.

In building zone 1 and the colder parts of zone 2, interior louvers for fans are preferred to exterior. Exterior louvers in these areas often freeze shut.

In adjusting controls for all fan-ventilated houses, a simple temperature distribution study of the house is useful to obtain uniform temperatures. A few inexpensive thermometers scattered about the house at bird level will indicate variable temperatures. In well-insulated and "airtight" houses, thermometer readings should not vary more than 3° to 4° F. between different parts of the house. In winter, a low temperature in one area indicates that too much air is coming in at this place. In summer, a temperature that rises faster in one area than in others indicates that too much air is coming in at this place. When these conditions are known, the poultryman can adjust controls to operate his fans most effectively.

Another way to check the temperature is to observe areas that hens do not occupy. These areas are too cold in winter or too hot in summer.

INSULATION AND WALL FINISH

Insulation is required to keep laying-house temperatures above freezing in zones 1 and 2 and in parts of zone 3. Roof insulation helps protect the chickens from summer heat, but should be used in combination with light-colored or reflective roof surfaces.

Many types of commercial insulation are available, including fill, batt, blanket, board, and reflective. Any insulation that is fire resistant and verminproof may be used if it has the required insulation value.

Dry wood and various farm wastes, such as shavings, sawdust, ground corncobs, and chopped straw, may be used for insulation. Verminproofing and fireproofing treatments are available for these materials. These farms wastes have slightly less insulation value per inch of thickness than have commercial insulation.

The values shown in table 3 are recommended as minimum values for winter insulation. To maintain a given inside temperature, smaller houses need more insulation than larger. The insulation values provided by different types of construction are shown in figure 23.

In insulated gable-roofed houses, the ceiling should be insulated instead of the roof, using fill or blanket insulation. The attic space must then be ventilated.

Several State agricultural colleges recommend the use of a straw loft, which both insulates and helps ventilate small laying houses. The usual depth recommended is about 10 to 12 inches of settled straw. Where space is available for more straw, as much as 24 inches may be used. Any clean straw is satisfactory, but chaffy straw or hay containing clover, alfalfa, or similar material is not suitable. Because of disease hazards, the use of a straw loft for insulation is not recommended for large laying houses.

The space above the insulated ceiling should be well ventilated, usually by louvers in the gable ends, to prevent moisture from condensing under the roof. The area of the louvers at each end of the house should be one-half to three-fourths of 1 percent of the floor area. If the house is unusually long, roof or ridge ventilators may also be needed.

For information concerning insulating a large laying house, consult extension poultrymen and agricultural engineers at the State agricultural college.

A suitable wall finish should be used inside the house. It should be able to withstand washing with hot water alone or with disinfectant in solution. The surface should be tough enough to withstand pecking wherever walls can be reached by the hens.

TABLE 3.—*Recommended minimum insulation values* [1] *for laying houses*

Location	R-value	
	Walls	Ceilings
Zone 1:		
Colder parts	8–10	10–15
Warmer parts	6	12
Zone 2	5	10
Zones 3 and 4	2	5

[1] Insulation value (R-value) is defined as the number of degrees difference in temperature between the inside and outside surfaces of a wall that will permit 1 British thermal unit (B.t.u.) of heat to pass through 1 square foot of the wall per hour.

VAPOR BARRIER

A vapor barrier is needed on the warm side of all insulated walls to prevent water vapor in the laying-house air from condensing in the insulation. Polyethylene film and asphalt-coated paper, 55-pound roll roofing, aluminum foil, or two coats of asphalt or aluminum-flake paint applied on an unbroken surface, all are satisfactory vapor barriers. Some commercial insulation materials have a vapor barrier attached. *Building paper is not a vapor barrier.*

Follow the manufacturer's instructions in applying the barrier and avoid tearing holes in it.

The outer-wall surface should have small vents so any moisture that gets into the insulation can escape. If vapor-resistant siding, such as roll roofing or asphalt, is used, ventilation to the stud spaces should be provided by small screened openings or slots (fig. 24, *A* and *B*).

Correct placing of the various materials in an insulated frame wall is shown in figure 24, *C*. The siding is placed over 15-pound building paper or felt, which is not a vapor barrier but is used to prevent rainwater or snow from reaching the insulation. The space between the studs may be insulated with farm wastes or commercial insulation. The vapor barrier is placed between the studs and the material used as an interior finish. When paint is used as the vapor barrier, it is applied to the surface of the interior finish facing the chickens.

On shed roofs that are insulated between rafters, a vapor barrier should be placed below the insulation, and an airspace of at least 1½ inches should be left under the roof sheathing. This airspace should be ventilated by screened slots under the roof boards at both ends of the rafters.

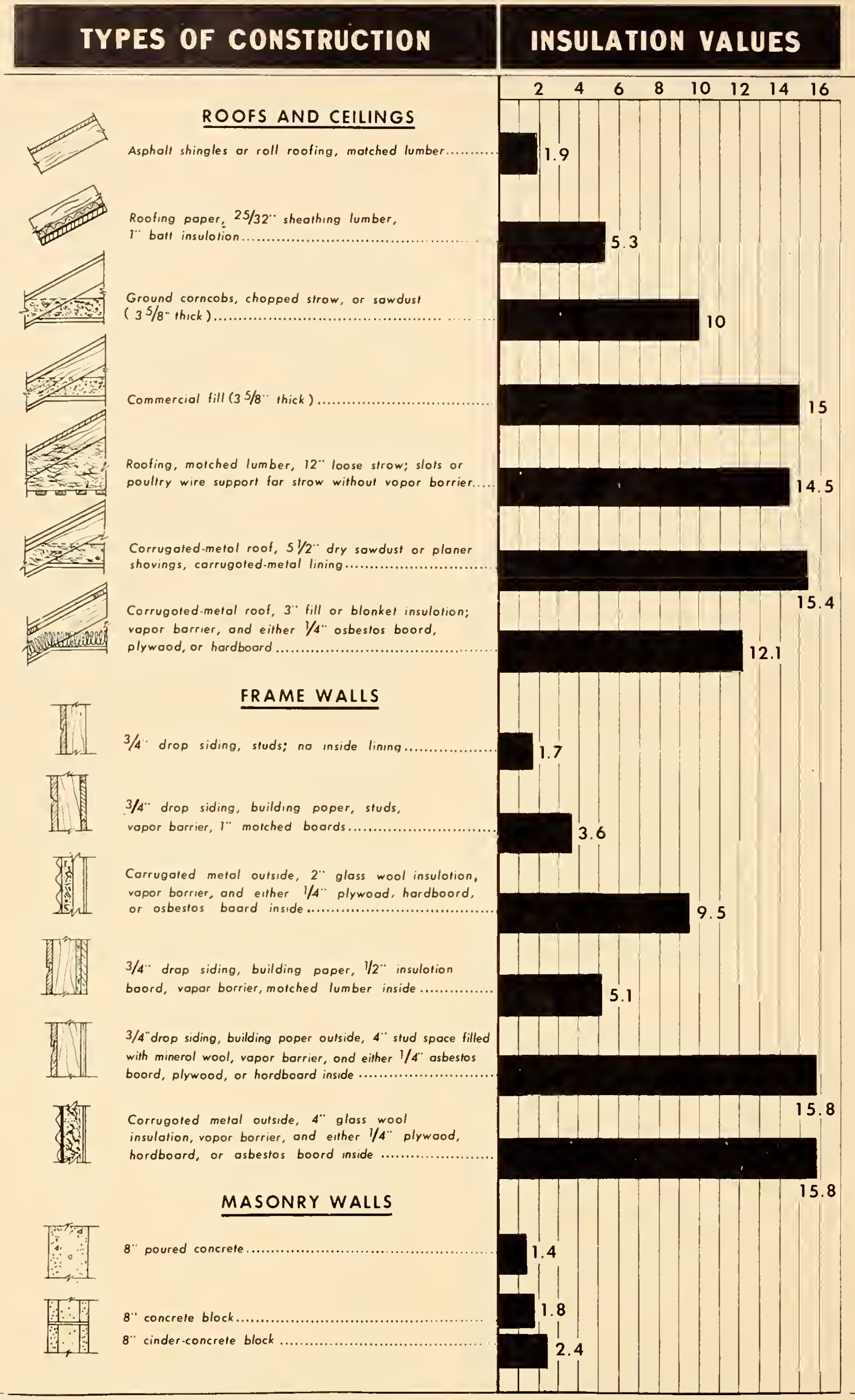


FIGURE 23.—Insulation values for common types of roof, ceiling, and wall construction. All attic spaces are considered ventilated.

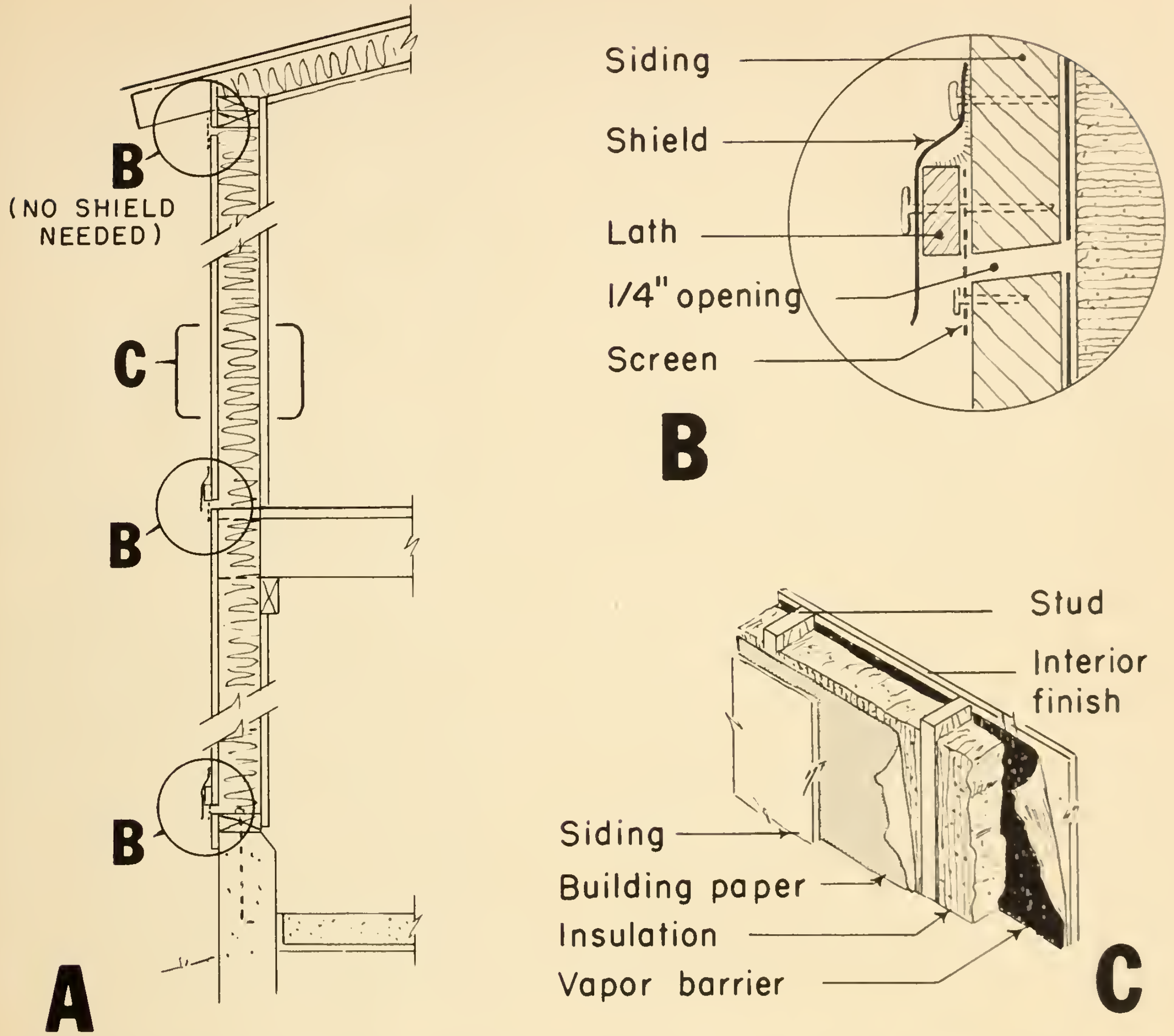


FIGURE 24.—Installation of insulation and vapor barrier: *A*, Ventilation to the stud spaces by means of small screened openings or slots; *B*, detail of small vent; *C*, correct placement of material in insulated frame wall.

BUILDING THE LAYING HOUSE

Construction Costs

Construction costs for materials and labor vary considerably in any given area. The cost of building a small house is considerably higher per hen than that of building a large house. In some areas, poultrymen reduce building costs by as much as 50 percent by using native lumber and other locally available materials and by employing family help.

Location and Orientation

For the farm flock, a site near other buildings saves time and travel and provides a certain amount of protection from thieves. Locating large laying houses 150 feet from other large structures reduces fire risk. The laying house should be where prevailing summer winds will not carry odors to the dwelling.

The site should be large enough to provide for expansion. Location of service roads, water supply, electric lines, and future buildings and yards should be considered.

A site on relatively high ground, with a south or southeast slope and good natural drainage, is

usually preferred. The foot of a slope where either soil or air drainage is poor, or where seepage occurs, is unsuitable. A site exposed to drainage from adjoining farms should be avoided because of the disease hazard.

If the house is on a hillside, the site should be graded to carry surface water away; and a tile drain should be placed along the upper side at footing level, connected to an open outlet or to a dry well at a lower level. A house on a steep slope should not face uphill, as air drainage down the hill makes control of ventilation difficult.

For winter comfort and good litter management, the small or medium-size house in most climates should face approximately south to obtain most sunlight and protection against northwest wind. Control of solar heat by shading the windows in summer is also more practical when the house faces south. However, the house should face east where prevailing winter storms are from the west. Wide houses are often placed with their long dimension north and south to have equal lighting on both sides.

For disease prevention, older hens should be separated from younger ones by at least 200 feet. The farmstead should be planned so that chore routes, summer wind, and water drainage lead from young to old stock.

Shade in summer is an advantage, but trees should be the kind that shed leaves in the fall. A well-mowed sod greatly reduces radiation of heat from the ground into the building. For fire protection, weeds and grass should be kept mowed around all buildings.

In zones 1 and 2, windbreaks 50 to 100 feet to windward of the laying house help to keep it warm and to prevent snow from drifting around the house. Shrubbery around the house is not recommended as it tends to trap heat in the summer and may shelter vermin.

Selecting a Plan

State agricultural colleges and the U.S. Department of Agriculture cooperate in preparing laying-house plans that meet requirements of the different parts of the United States. These plans may be ordered from the county agent, but *not* from the Department of Agriculture. Most county agents have catalogs that illustrate these plans.

Some manufacturers of building materials distribute laying-house plans through lumberyards and other dealers. Other plans are available from publishers of poultry magazines and equipment manufacturers.

The following points should be considered when selecting a laying-house plan:

Type of house.—The house may be open, open front, insulated, windowless, single or multiple story.

Size of house.—Insurance companies recommend that the maximum capacity of the house not exceed 5,000 hens.

Width of house.—The more nearly square the house, the less wall area there is in proportion to the floor area. Other things being equal, the wide or nearly square house is cheaper to build and warmer in winter than the long, narrow house. The maximum practical width is 50 to 60 feet, but many prefer houses not more than 40 feet wide.

Possible changes in type of farming.—Headroom and spacing of columns should be planned so the building may later be used to store machinery, to shelter other livestock, or for other purposes if a change in type of farming is made.

Spacing of partitions.—Many poultrymen prefer that laying hens be penned in groups of not more than about 500 or 600. Sick and cull birds can be readily seen in flocks of this size.

Cross-partitions strongly built to brace the building against high winds should be spaced not more than 1½ times the width of the building. With this spacing, the area between brace partitions in a house 24 feet wide is 864 square feet. The area between brace partitions in a 50-foot-wide house is 3,750 square feet. One or more wire partitions may be used to divide this space.

Wall openings needed for summer ventilation.—See table 2, p. 9.

Insulation required.—This is determined by the type and size of the house, the desired bird density, and the climate in which the house is to be built.

Size of doorways, spacing of supports, and height of ceiling.—The dimensions and spacings of these items depend on whether or not tractor equipment is to be used to clean the house. Minimum width of a door for a farm tractor is about 8 feet and the height from 7 to 8 feet, depending on the design of the tractor. Small garden-type tractors, especially designed for cages and houses with litter floors, are available from poultry-equipment manufacturers.

Selecting Building Materials

Wood, concrete or cinder blocks, and clay tile walls on concrete or masonry foundations have been used satisfactorily for laying houses for many years. Use of metal roofing and siding has increased since World War II. The use of pressure-treated poles and planks for foundation and wall framing is popular.

Any one of these types of construction is satisfactory if it provides: Structural strength to resist wind and snow loads and to carry the weight of hens, feed, litter, and other contents; insulating value sufficient to maintain the desired temperature in the house; and reasonable initial cost and upkeep expense.

Prefabricated houses of all types and sizes are on the market. A prefabricated house may meet requirements more economically than one built on the site, and it can be erected much more quickly. Since it is not economical to make changes in a house of this type, the plan and description should be studied carefully before the house is purchased.

Building Details

If a suitable plan for the house has been selected, the blueprints should show the necessary construction details. If the design is changed, a qualified engineer or builder should be consulted to see that the construction is strong enough. For example, if a thin concrete slab is substituted for a wood floor, or if a feedbin is installed on an upper floor, the joist, column, and footing sizes should probably be increased. The points discussed in the following paragraphs are emphasized because they are often neglected.

Severe wind storms—for example, "Hurricane Hazel" in 1954—have destroyed many laying houses on farms where dwellings and barns were left unharmed. Examination of many laying-house facilities showed that weak construction of foundation and framing and lack of cross-partitions in long houses were largely responsible for these failures. Details showing good construction practices for hurricane areas may be found in U.S. Department of Agriculture Information Bulletin 144, "Preventing Storm Wind Damage to Farm Buildings."[1]

Foundations and Footing

Foundations must have sufficient weight or grip on the ground to hold the building down; 18-inch depth is the minimum in areas subject to windstorms. Greater depth may be needed, depending on local soil and frost conditions. For a permanent structure, a continuous footing (fig. 25) of poured concrete spreads the weight of the building evenly. Steel reinforcement may be necessary where soil is soft and drainage is poor.

In frame houses, anchor bolts should extend into the footing if the foundation wall is of concrete blocks (fig. 25). If the wall is poured concrete, ½-inch bolts, set at least 6 inches into the top of the concrete, and spaced every 6 feet, are generally satisfactory, except in hurricane areas. Large washers should be used on top of sills.

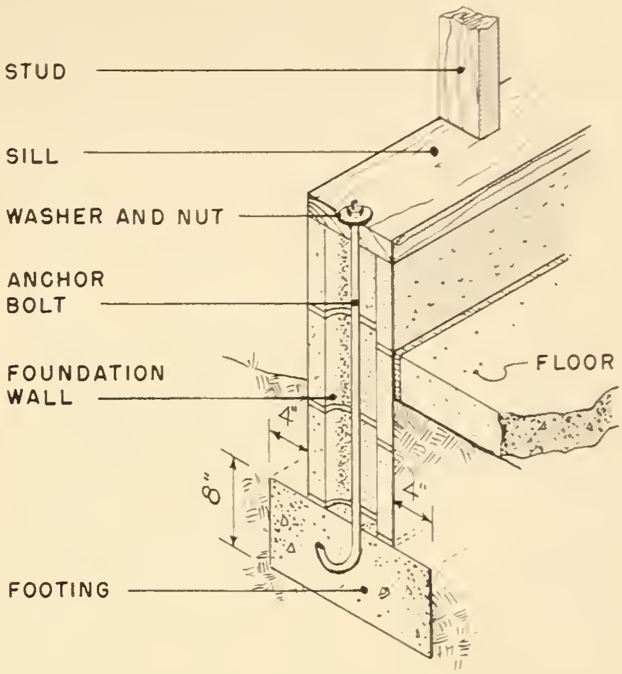


FIGURE 25.—Detail of foundation and footing. Note that anchor bolt extends into footing.

Piers for posts and columns (fig. 26) should be carefully made of concrete because a relatively small bearing area carries several times the load of an equal area along the foundation wall. The footing sizes and depths shown on plans approved by the State agricultural college should be followed.

The size of footings for interior posts is extremely important, both in supporting the weight of the building and its contents and in resisting uplift during windstorms. The top of the pier should be at least 3 inches above the litter and usually 8 to 12 inches above the floor. Dowels (pegs) should not be depended on to hold posts on piers. Imbed a steel U-strap into the footing and lag screw or bolt it to the post (fig. 26).

Floors

Detail of floor construction is shown in figure 27. A floor in contact with the ground is warmer in winter and cooler in summer than one that is above a shallow crawl space. A concrete floor is generally preferred as it is smooth enough to permit easy removal of litter, can be disinfected, and helps keep out rodents.

Dirt, gravel, and limestone floors are widely used but cannot be satisfactorily disinfected.

[1] For sale only, by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Please use your Zip code when ordering.

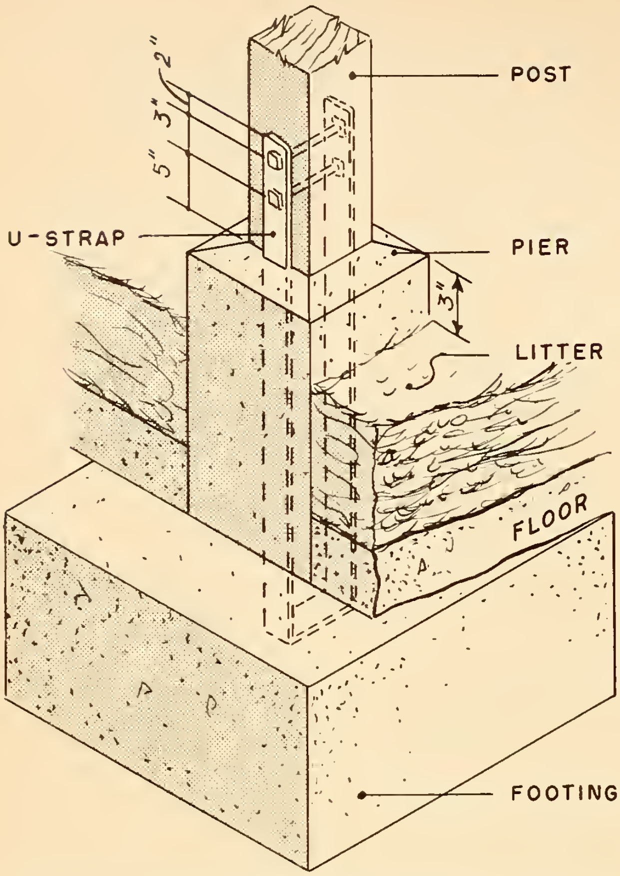


FIGURE 26.—Detail of pier and anchor for posts. Note that U-strap extends into footing.

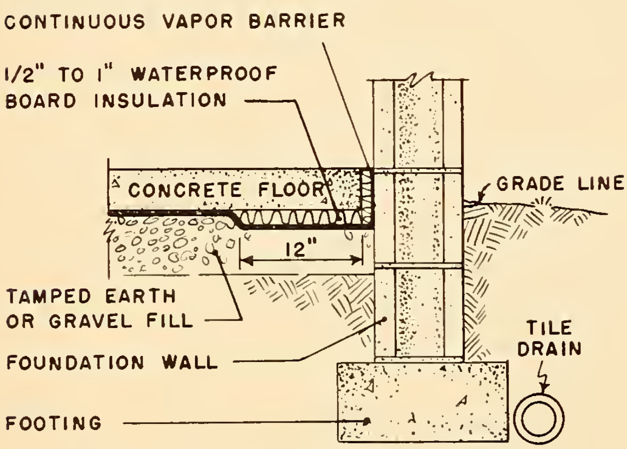


FIGURE 27.—Detail of floor construction.

Since they are cheap, they enable a new poultryman to keep his investment as low as possible until he can afford to lay concrete.

Floors of concrete, dirt, or similar material should be raised 8 or more inches above the surrounding ground. Where seepage is a problem, some State agricultural colleges recommend placing a 4- to 6-inch gravel fill under the floor for drainage. A layer of 55-pound roll roofing or polyethylene film, overlapped about 2 inches at the joints, makes an effective moisture barrier between the floor and the subgrade. In building zone 1 and in the cooler parts of zone 2, a 1-inch-thick strip of waterproof insulation between the floor and the outside wall helps keep the house warm and reduce condensation on the floor.

A 3- to 4-inch thickness of well-mixed concrete (1 part cement, 2 parts sand, and 4 parts gravel), laid on a well-tamped base, usually can support the tractor and manure spreader used in cleaning the house. If the floor is to be scrubbed, it should be sloped toward one or more doorways for drainage.

A wood floor is generally used for the upper stories of multistory houses. Flooring should not splinter badly when scraped. Edge-grain fir and yellow pine are suitable. Sometimes a 2-inch thickness of concrete is laid over wood boards or galvanized sheet metal. This adds about 25 pounds per square foot to the load on the floor joists, posts, and footings; the construction should therefore be strong enough to carry this additional load.

Wood Framing

Long houses should be strengthened against wind by solid partitions spaced not more than 1½ times the width of the building. End walls and solid partitions must be braced either by diagonal bracing (fig. 28) or by boards applied diagonally. In multistory buildings, 1- by 4-inch braces should be used for the top story, and 1- by 8-inch braces for lower stories.

Connections between the foundation and the walls must be sound. Anchor bolts should be used through sills; studs should either be toenailed to the sill with five tenpenny nails or tied with 22-gage steel strapping or with special fasteners.

The connections between wall and roof are important. Either steel strapping or commercial steel anchors (fig. 29) should be used to tie plates to studs and rafters to plates. The upper half of the plate should be bolted to the lower half with ½-inch bolts, placed 4 feet apart.

Connections of center post to girder and girder to rafters, using steel strapping, are shown in figure 30. The strap is fastened to the post with ⅜- by 2½-inch lag screws. Plumber's strapping or commercial anchors are used to tie rafters to girders. Failure from wind damage often occurs here, especially in buildings with roofs that are nearly flat or shed type.

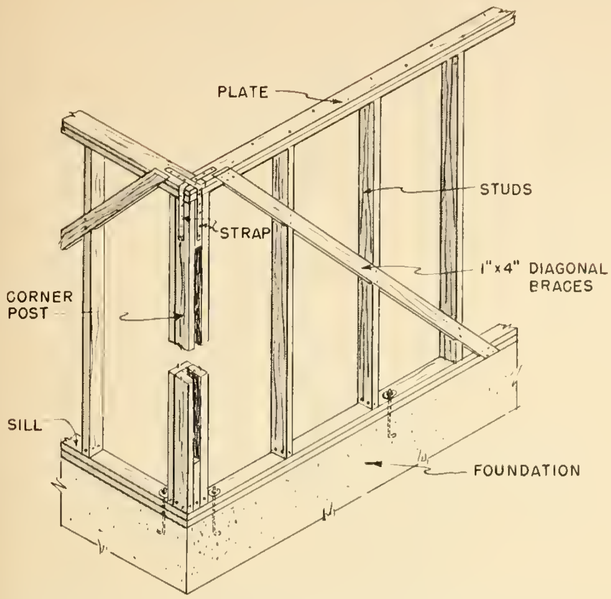


FIGURE 28.—Diagonal bracing and steel strapping used to strengthen end walls.

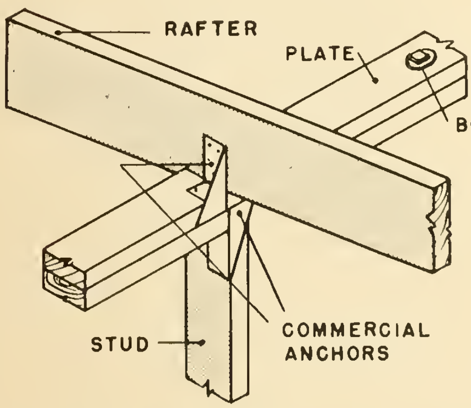


FIGURE 29.—Commercial anchors used to tie plates to studs and rafters to plates.

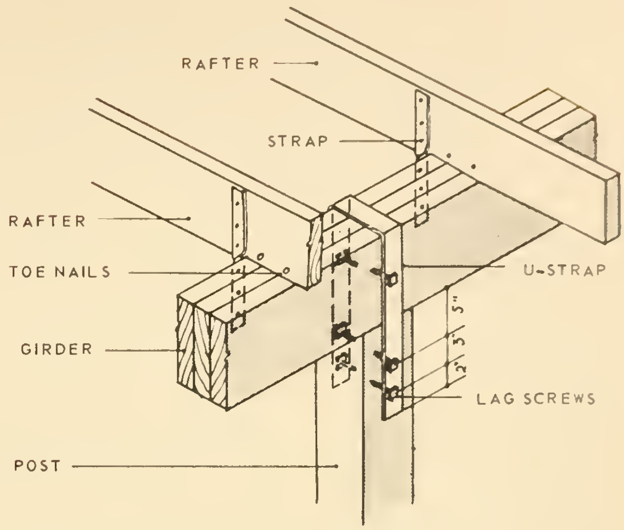


FIGURE 30.—U-strap, 2¼- by 3/16-inch, used to tie girder to post.

As masonry-block walls are often damaged by stormwinds, special care should be given to quality of workmanship and to tying the walls to floors and roof. U.S. Department of Agriculture Information Bulletin 144, "Preventing Storm Wind Damage to Farm Buildings," shows simple means of strengthening both masonry and wood-frame buildings.

Roof Covering

The roof is exposed to a greater sunshine-heating load than any other part of a building, and it also provides the best heat-radiating surface at night. On a still, clear day, the temperature of a roof with a black upper surface may be 50° F. or more above the outdoor air temperature. Where summer comfort of the hens is most important, the surface of the roofing material should be white or light colored. If a dark-colored roof has already been installed, it may be whitewashed before hot weather begins.

The American Zinc Institute, in cooperation with the Universities of Alabama, Florida, and Kentucky, developed whitewash formulas for roof application (table 4). These mixtures can be applied to clean, unrusted galvanized sheet metal. Both hydrated lime and white cement are available at farm and hardware stores. Retail paint dealers can obtain the polyvinyl acetate.

The whitewash requires thorough mixing and is readily applied with a whitewash brush or broom. For hand sprayer or pressure application, the mixture is strained through a window screen. A hand sprayer of the trombone type can easily apply the whitewash. Less whitewash is needed when applied with a sprayer than with a brush.

If the roof is rusted, first apply a zinc dust-zinc oxide primer (metallic zinc paint) and then an outside white paint that chalks or self-cleans.

For roofs with little slope.—Built-up bituminous roofing can be used on roofs that have very little slope. It is often applied by roofing contractors. Asphalt roll roofing with cemented joints is usually used on roofs that have from 2 to 4-inch slope per foot. It may also be used on roofs having a steeper slope.

Single-ply roll roofing is most commonly used for nearly flat roofs, but the life of such roofs is usually short. Wide-selvage roll roofing that gives double coverage, with the upper ply cemented to the lower, is considerably more durable

TABLE 4.—*Whitewash formulas to reduce summer temperature of nonrusted galvanized sheet metal roofing*

Formula	Area covered	Summers effective	Cost of material
	Square feet	*Number*	*Dollars*
20 lb. hydrated lime plus—			
5 gal. water	600	1	0.30
6 gal. water plus 20 lb. white cement	700	3	1.00
5 gal. water plus 1 qt. polyvinyl acetate	700	4	.75

than ordinary roll roofing. However, it costs about twice as much.

When built-up bituminous roofing is used on an insulated house, the space between the roof and the insulation should be ventilated to allow escape of moisture that leaks through a punctured vapor barrier or through other openings or cracks in the building.

For roofs with steep slope.—For roofs that slope 4 inches or more per foot, asphalt shingles and sheet metal roofing can be used. Asphalt shingles look better than roll roofings. The lock-down type of shingle is more resistant to wind damage than the rectangular-strip shingles. The tabs of rectangular shingles should be cemented down. Manufacturers' recommendations should be carefully followed for best results in applying metal and other roofing materials.

The U.S. Department of Agriculture Farmers' Bulletin 2170, "Roofing Farm Buildings," gives information on types and selection of roofing and on estimating costs of roofing and roof repair.

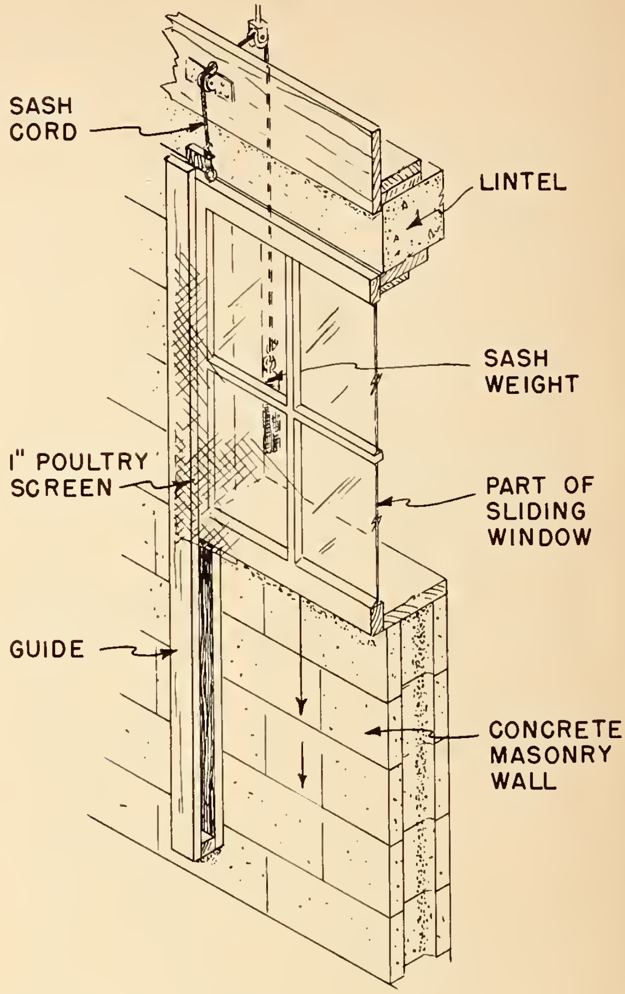


FIGURE 31.—Counterbalanced window hung outside masonary wall.

Windows

Numerous designs for windows are satisfactory. None are perfect; all require maintenance. One type often used for the laying house is the counterbalanced window outside a masonry wall (fig. 31). These require more maintenance than those sliding into the frame wall (fig. 32). Some poultrymen are now using windows with aluminum sashes. These require less maintenance than windows with wood sashes.

In the warmer climates, heavy unbleached muslin or a glass substitute is sometimes used in place of glass on a wooden frame. Cloth or fabric underneath the molding strips should be waterproofed to prevent rotting. The bottom should be tacked to the frame but not covered with molding.

Windows on the north side of the house in zones 1 and 2 should be weatherstripped to stop drafts. Windows shown in figures 31 and 32 cannot easily be weatherstripped. Storm windows or windows of double glass are desirable in zone 1. If windows are not needed for light, wood or plywood shutters may be used.

Window openings should be screened with ½-inch mesh hardware cloth to keep out wild birds. Screening on the inside prevents hens from roosting on the sills.

Shutters hinged at the top and opening outward help to keep out summer sunshine. These shades (fig. 33) can be made of such materials as metal, pressed wood, or plywood.

Interior Details

For large flocks, the time required to feed and water, gather eggs, and observe the hens may vary from 20 minutes to 2 hours per day per 1,000

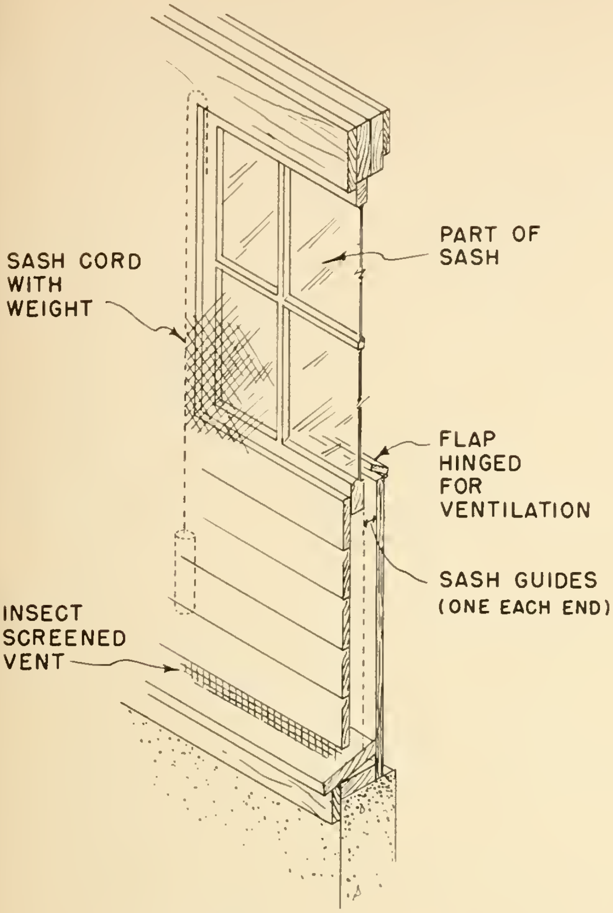


FIGURE 32.—Counterbalanced window sliding into frame wall.

layers. Persons tending a flock may walk as much as 500 miles per year. As much as 50 percent of chore time may be spent in handling and collecting eggs. These figures do not include large cleaning jobs that must be done occasionally. It is important, therefore, to consider carefully the selection and arrangement of equipment, laborsaving devices, and other interior details.

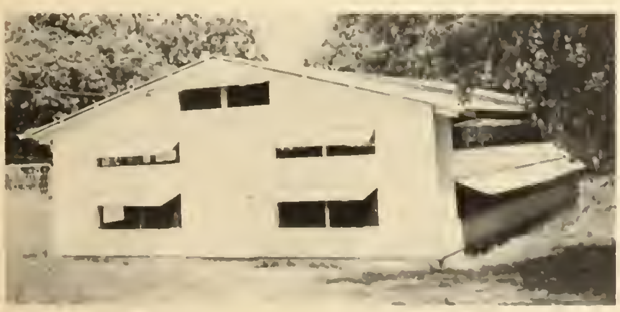


FIGURE 33.—Shutters hinged to serve as shades.

A diagram of an expandible (repeat pen) floor plan designed to save labor and time in a large laying house is shown in figure 34. The nests are near the egg-handling and egg-cooling rooms.

Nests

Commercial-type nests are easily cleaned, and ease of cleaning is important. Two types of commercial nests are in general use—individual and community (or colony).

Individual nests are just large enough for one hen (fig. 3). Some have an egg rollout floor and tray that may also be incorporated with a belt egg conveyor. Some nests with a mechanical egg conveyor have a plasticized-wire egg rollout floor. The usual dimensions of an individual nest are 10 to 12 inches wide, 12 to 14 inches high, and about 12 inches deep. From 1 to 2 inches of nesting material is needed for each nest. One nest is needed for 4 or 5 hens. A 4- to 6-inch landing, or jump, perch in front of the nest, covered with either ½-inch mesh hardware cloth or 1- by 2-inch welded wire, will help keep the nests clean. Some poultrymen keep hens from roosting in the nest at night by hinging the perch to fold against the opening of the nests.

Prefabricated community nests, which accommodate several layers at one time, are shown in figure 35. These nests are available with rollout floor and egg tray.

Satisfactory rollout floors for community nests can be made by the poultryman by using ½- by 1-inch, 16-gage, welded-wire fabric. The floor should have a 1¼- to 1½-inch slope. A nest 2 feet wide by 4 feet long is sufficient for about 40 hens. One 8-inch square entrance is needed for each 2- by 4-foot nest.

As several hens use the community nest at one time, ventilation is important. A 1-inch wide crack at the top of the nest allows heated air to escape.

The trap nest is not ordinarily used by market-egg producers. Trap nests enable poultrymen to keep individual egg-laying records of the hens. These nests require frequent egg collecting to free the hens. One nest for about four hens is sufficient.

Feeders for Mash, Oystershell, and Grit

When the hens are hand-fed, at least 40 linear feet of trough space is required per 100 hens. A strip of 1- by 2-inch mesh welded wire may be placed on top of the feed to prevent the chickens from spilling it from the trough.

Readymade metal feeders are generally used.

To produce eggs with good shells, the hens must have limestone or oystershell in their diets. Normally, 100 hens consume about 1½ to 2 or more pounds of oystershell per day, depending on air

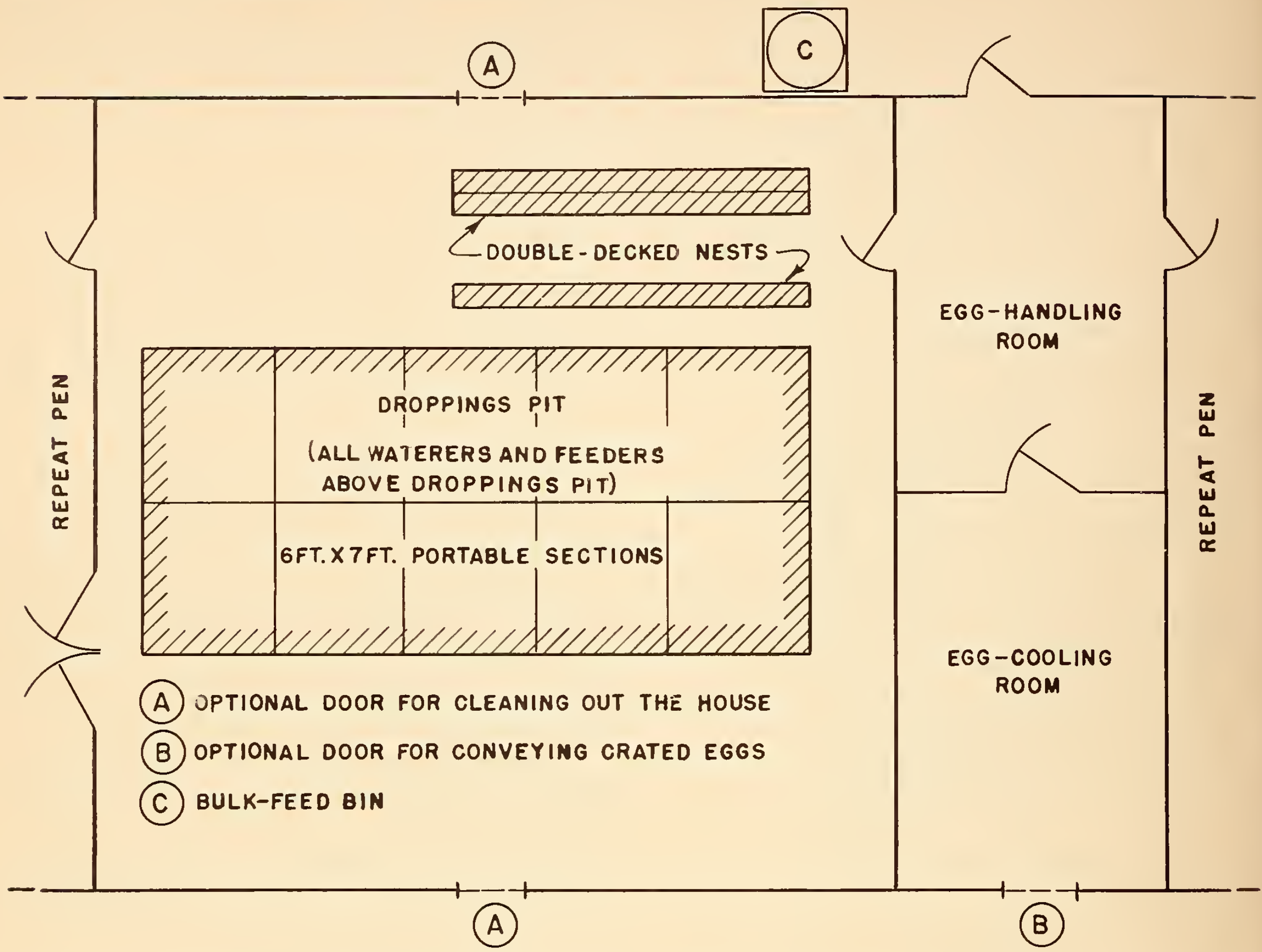


FIGURE 34.—Diagram of an expandible (repeat pen) floor plan designed to save labor and time in a large laying house.

temperatures, feed consumption, and egg production. The consumption of calcium increases during warm weather, and an ample supply should be kept in the hopper at all times. A 12-inch hopper for grit and another of the same size for oystershell are sufficient for 100 hens.

FIGURE 35.—Community nests showing eggs rolled to a belt egg conveyor.

Mechanical feeders (fig. 1) have become popular in large houses. These help poultrymen to handle large flocks. There is some disagreement as to the best size of flock for economical use of such feeders. Improved feed-hopper design has greatly increased the efficiency of these machines. Local feed dealers may contact mechanical-feeder manufacturers for assistance in laying out the equipment.

Waterers and Piping Water to Fountains

Buckets, pans, and other hand-filled waterers are used for small flocks. When the flock is large, much time is saved by piping the water to fountains. Watering devices may be automatically controlled, or they may be the continuous-flow type.

Automatically controlled waterers include fountains that maintain a specified depth or weight of water. This type usually requires from 4 to 5

gallons of water per day per 100 hens; however, in summer it requires as many as 9 gallons. A tank is often connected to the pipeline to furnish a reserve supply if power fails and to provide a convenient means of adding medication.

In the continuous-flow type of waterers, the water level is kept just high enough in a V-shaped trough to permit the hens to drink. Fluctuating pressure in the pipelines makes it difficult to adjust the needle valves in a continuous-flow system. To overcome this difficulty, the waterers may be fed from a gravity tank filled from a pressure line with float-valve control. If the rate of flow is fast enough, the water does not freeze. The drainage system must be able to handle the continuous flow of water.

For 100 hens, a 5-foot trough accessible on both sides is required with either system. In summer and in warm areas, watering space may have to be doubled.

A fountain should be placed either on a platform made of 1- by 2-inch mesh welded-wire floor, 30 to 36 inches wide and raised 3 to 4 inches higher than the expected litter depth, or above a drain. Watering with this arrangement will lessen the amount of wet litter surrounding the fountain.

Except in warm areas or in houses that are so warmly built that there is no danger of freezing inside, waterers need protection from frost. Thermostatically controlled heaters are available for maintaining ice-free fountains.

Water pipes should be laid underground to protect them from frost in winter, to keep them out of the way, and to keep the water cool in summer. Rubber hose, galvanized-steel pipes, or plastic pipes may be used. Copper pipes are corroded by ammonia fumes and therefore should not be exposed to air in the house. Galvanized-steel pipes will corrode when laid in cinder fill.

Either a ½-inch galvanized-steel pipe or a ⅜-inch plastic pipe will supply water for a large number of hens. If water is also used for washing down the inside of a house, for roof sprinklers, or for special nozzles for fogging, a pipe at least three-fourths inch in diameter will be needed. The size of the pipe will depend on the size of the house.

Water pipes exposed to low temperature may be protected from freezing by an electric heating cable. Electric heating wire installed in the waterline is shown in figure 36, *A*. This heating wire is about one-eighth inch in outside diameter and is covered with water-resistant material. Plastic-covered soil-heating wire is also satisfactory. Two special compression fittings are needed at each end of the heating wire, and a thermostat is needed to operate the heater. The wire shown on top of the pipe is an ordinary No. 14 rubber-covered copper return wire. The pipe

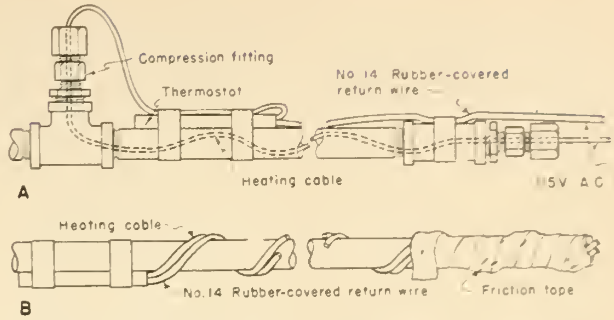


FIGURE 36.—Two methods used to heat water pipes with cable: *A*, Heating cable inside the pipe and rubber-covered return wire outside the pipe; *B*, heating cable and return wire outside the pipe, protected by friction tape or insulation tape.

must be grounded as protection against possible electric shock.

An alternative method, in which about twice as much electric energy is used, is shown in figure 36, *B*. In this method, more heating wire is also required. The heating and the return wires should be spiraled in parallel, as shown. The wires are covered with friction tape or pipe insulation.

The amounts of electrical energy needed to maintain ice-free water in pipes at various house temperatures are given in table 5. These are the values for the two methods illustrated in figure 36. For example, if 220 feet of ½-inch pipe in a house needs frost protection at an expected low house temperature of 20° F. and the heating wire is installed inside the pipe, a total of 185 watts $\left(\frac{220}{100}\times 84\right)$ will be needed. If refrigeration insulation tape is used to wrap the pipe, less energy will be used. The agricultural engineer of the local power company should be consulted about the

TABLE 5.—*Amounts of electrical energy needed to maintain ice-free water in pipes at various temperatures (University of California)*

Method of heating	Energy per foot per ° F. below 32°	Energy per 100 feet of pipe at various house temperatures			
		0° F.	10° F.	20° F.	30° F
Cable through pipe:	*Watt*	*Watts*	*Watts*	*Watts*	*Watts*
½-inch	0.07	224	154	84	14
¾-inch	.10	320	220	120	20
Cable spiraled around pipe:					
½-inch	.17	544	374	204	34
¾-inch	.20	640	440	240	40

length, resistance, and wire size of the heating cable.

Many poultry-equipment manufacturers can supply suitable heating cables to prevent freezing of exposed water pipes and waterers.

Droppings Pit, Droppings Board, Roosts, and Utility Pit

The droppings pit, with roosts above it, is designed to accumulate droppings for several months. A typical pit is shown in figure 37. Portable droppings pit sections may be made of 1- by 2-inch wire cloth or wood slats. When the pit is boxed in, the maximum length of the section should be from 7 to 8 feet for easy culling and cleaning. When pits are against the wall, some poultrymen prefer to keep them less than 6 feet wide for easy culling. When pits are in the center of the house, they should not be more than 14 feet wide. For easy handling of the pit enclosure, the roosts and walls can be constructed separately so they can be moved.

A typical droppings board is shown in figure 38. The open space under the board provides additional floorspace for the hens. The roosts are generally hinged to the wall and raised when the droppings board is cleaned.

Roosts (perches) should be of 2-inch stock, rounded or beveled on the upper edges. For use in hot weather, roosts should provide 8 inches of space per hen for small breeds and 8 to 10 inches for large breeds. Roosts are usually 13 to 15 inches apart.

The flock size may be increased by locating feeders, roosts, and waters in tiers over a mechanically cleaned utility pit (fig. 4). About 75 percent of the droppings may be collected in such pits. Frequent removal of droppings will aid in keeping litter and house dry in winter. A complete, prefabricated unit of feeders, waterers, nests, and mechanical pit cleaners is available.

Feed Room

The feed room may include space for supplies and feedstuffs, workbench, egg handling, and egg

FIGURE 37.—Droppings pit built along rear wall in a prefabricated metal laying house.

FIGURE 38.—Droppings board built along rear wall of laying house.

cooling. The egg-handling and egg-cooling spaces should be walled off to keep dust from settling on the equipment, packing cases, and supplies, and to aid temperature control.

To calculate requirements and space for feedstuff, it can be assumed that in 1 day 100 hens will eat 30 pounds of all-mash or grain-and-mash diet. Thus, for 10 days, space for 300 pounds of all-mash or 150 pounds each of grain and mash is required. To offset feed-delivery difficulties during bad weather, space for at least an extra 2 days' supply is desirable. To calculate storage space requirements, use table 6.

In many areas, feed is delivered in bulk to save time, cost, and handling of bagged feed. Roads leading to the laying house should be surfaced to withstand 20 to 22 tons of feed delivered in trucks. A road clearance of 12 or 13 feet and space in which to turn around are required. The feed dealer should be consulted regarding location and height of bins and other details of bulk-feed delivery. Poultrymen in grain-producing areas often find it convenient to store an entire year's supply of feed at harvesttime.

Manufacturers' plans of feedbins constructed of plywood, pressboard, or steel are available through lumber and poultry-equipment dealers (figs. 2, 12.

TABLE 6.—*Weight and space requirements for various feeds* [1]

Feed	Weight per cubic foot	Space per ton
Grain:	*Pounds*	*Cubic feet*
Barley	40	50
Corn, shelled [2]	44	45
Grain sorghum or milo	41	49
Oats	28	72
Soybeans	46	44
Wheat	48	42
Mash:		
Finely ground	29	69
Coarsely ground	34	59
Crumbled	34	59
Pelletized, hen size	37	54
Middlings, loose	25	80

[1] 1 bushel = 2,150 cubic inches, or 1.24 cubic feet

[2] Ear corn occupies about twice as much space as shelled corn.

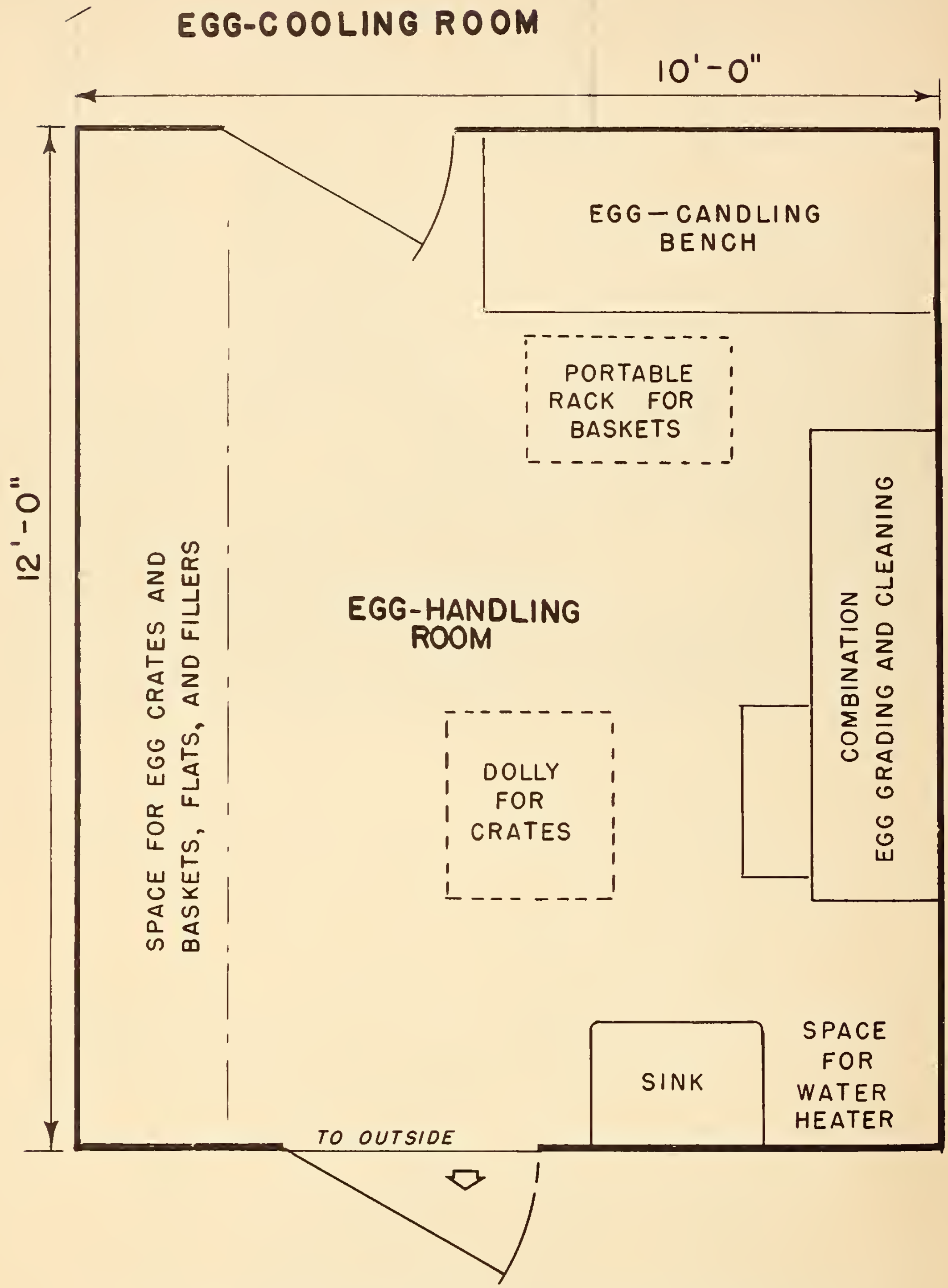


FIGURE 39.—Typical floor plan for egg-handling room for a flock of 1,000 or 5,000 hens.

13, and 14). A few manufacturers make steel hopper bottoms for which farmers can build walls, roofs, and supports. Some agricultural county agent have plans for bulk-feed bins. Consult an engineer to design unusually large bins.

The following construction details for bins are especially important:

- Exterior walls and roof should be tight to prevent rain or snow from entering and to permit effective fumigation if needed.
- If bin is exposed to sun, white or aluminum-colored paint or material should be used.
- Smooth inside walls are needed.
- Bins should not be located on an upper floor without proper support.
- Spouts for emptying bins used for storing mash should be about 10 by 12 inches.
- A flat steel door about one-eighth inch thick and sliding in a metal groove is most satisfactory for large bins.

Figures 12 and 13 show prefabricated feed-storage bins outside the poultry house. Feed is moved into the house with a conveyor to automatic feeders or hand carts.

Egg-Handling Room or Workroom

On most small farms, a separate egg-handling room or workroom (fig. 39) for cleaning, grading, and packing eggs may be in a cool, clean home basement. If more than 10 cases of eggs are produced per week, the egg-handling room should be near or in the laying house. The room should be so located that it can be easily and inexpensively expanded later. One end of the feed room is also satisfactory but the egg-handling room should be walled off to keep out dust.

A smooth floor makes cleaning and moving wheeled equipment easier. A slope of one-eighth inch per foot to a drain is satisfactory for concrete floors. Floors should be kept as dry and clean as possible.

Inexpensive automatic humidifiers will provide additional humidity if necessary.

The following approximate floor areas are suggested for the egg-handling room to permit convenient arrangement of equipment for egg grading and packing, for moving filled cases of eggs, and for storing empty egg baskets and a few days' supply of empty cases:

Laying hens Number	*Egg-handling room area Square feet*
1,000	80–100
5,000	100–150
10,000	200–225

Since floorspace requirements for automatic egg cleaners and graders vary, a simple scaled cutout of the particular make of equipment will help in planning the layout. A typical floor plan is shown in figure 39. The placement of egg cleaners, candling benches, and graders depends on the daily work routine. Ample space is needed to move filled egg crates and baskets. Hand trucks, dollies, and pallets save time and labor. A water heater may be desirable on a farm where eggs are washed.

If the worker is standing, convenient heights for tables on which to pack egg crates are 27 inches for a worker 6 feet tall and 24 inches for a worker 5½ feet tall.

Egg-Cooling Room or Cabinet

Since eggs deteriorate rapidly in warm, dry, or odorous places, they must be kept in a well-planned egg-cooling room or cabinet.

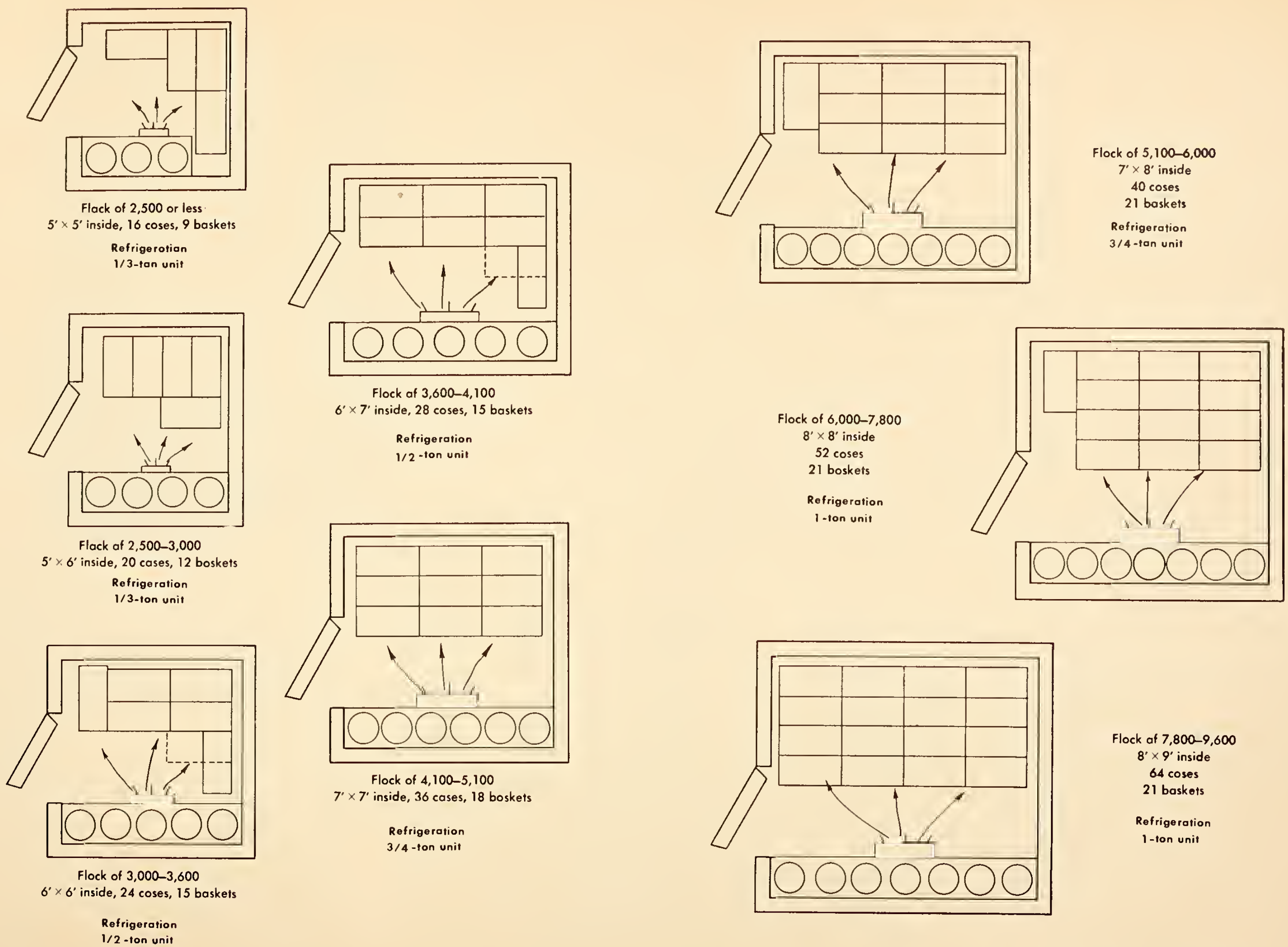
Eggs that are to be held should be cooled to 55° to 60° F. in less than 6 hours. If eggs are for hatching, the temperature should be kept at 55°. Relative humidity of the room or cabinet should be 75 to 85 percent. Inexpensive automatic humidifers will maintain this humidity.

For safe handling, egg baskets should not be more than three-fourths full. The baskets should be either hung or placed on slatted shelves, on racks with casters (fig. 40), or on fixed racks.

The size of the cooling room or cabinet depends on the size of the flock and the frequency of delivery of eggs to market. In most places, eggs are sold twice weekly; enough holding space for 4 days' eggs should therefore be provided. Prefabricated egg-cooling rooms or cabinets, complete with proper controls and refrigeration units, are available.

The nearer the room or cabinet is to cubical shape, the less surface is exposed to heat, and the less building material is needed. As filled egg crates are not usually stacked more than five high, the minimum ceiling height should be 7 feet for

FIGURE 40.—Portable racks for egg baskets in egg-cooling room.



Source: University of California

FIGURE 41.—Floor plans for egg-cooling rooms of various sizes, with approximate refrigeration needs in tons. Each room has three tiers of precooling shelves shown by circles, and the recommended method of stacking egg cases four high is shown by rectangles.

the walk-in cooler. Cabinet coolers holding fewer than 16 cases of eggs may be 5 to 6 feet high.

Floor plans for egg-cooling rooms of various sizes are shown in figure 41, together with the approximate size of refrigeration unit for each size of room. Each room has shelves for egg baskets, stacked egg crates, and blast-cooling coils. These plans are designed for farms that sell eggs twice weekly.

For simplest egg-cooling room construction, 2- by 4-inch studs, spaced 24 inches apart, may be used for framing. Inside and outside walls and ceiling may be finished with pressboard, exterior grade plywood, or other moisture-resistant material. The space between the "2 by 4's" should be insulated with a nonsettling type of insulating material. Such insulation includes the semirigid type of batt and blanket or the rigid type of preformed block.

The most satisfactory floor for the egg-cooling room or cabinet is 3- to 4-inch thick concrete, sloped one-eighth inch per foot to a drain. This floor, when laid over ground, should have a minimum of 3-inch gravel fill below it. If it is laid over an existing floor that is exposed to outdoor air temperature, the floor of the egg-cooling room or cabinet should have the same amount of insulation as the walls or ceiling.

The doors of most egg-cooling rooms are sources of considerable heat gain because of thin, poor construction. These doors should be thick and as well insulated as the walls and ceiling. A safety latch should be installed so the door can be opened from the inside.

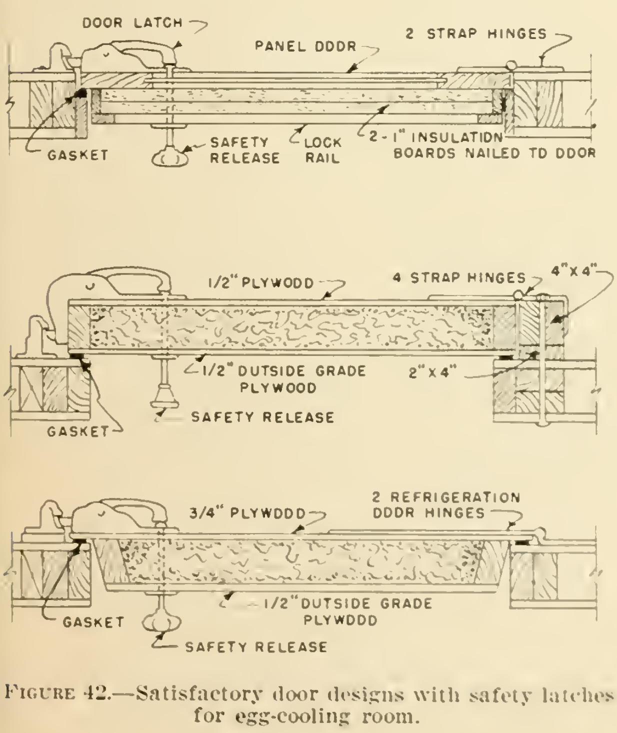


FIGURE 42.—Satisfactory door designs with safety latches for egg-cooling room.

When dollies or hand trucks are used, a threshold is not provided on the doorframe. Instead, a strip of reinforced rubber, one-half inch thick and 2 inches wide, is attached to the bottom of the door so heavy, cool air from the egg-cooling room does not leak out. Satisfactory door designs with safety latches are shown in figure 42. Airtightness of a door can be easily checked by attempting to slide a small sheet of writing paper between the gasket and the doorframe. If the paper slides easily in one place, strips of plastic friction tape may be used to build up the doorframing.

Properly designed egg-cooling rooms or cabinets are available from poultry-equipment manufacturers.

As eggs are precooled in the baskets before they are packed, the egg-cooling room should not be warmed when the main door is opened. One way to avoid this is to insert a small opening in the wall at waist height through which egg crates and baskets may be removed (fig. 13).

If the egg-cooling room is to be painted, use odorless paint especially manufactured for rooms containing fresh foodstuffs; otherwise, eggs will take on the odor of the paint.

Nearly all refrigeration units on poultry farms are air-cooled. These units resemble window-type air conditioners, but they are especially designed for egg-cooling rooms or cabinets. Blast cooling coils may be used (fig. 41). The fans on the coils should run continually. These coils should operate without frosting.

For economical operation of the compressor unit, both the hot and cold sides of the refrigeration unit should be kept clean.

Electrical Outlets, Lights, and Standby Generators

During fall and winter or on cloudy or foggy days, artificial lights maintain egg production. A total daily light period of 13 to 14 hours is sufficient. The preferred method is to turn the lights on by an automatic time clock early in the morning. There should be one 40- to 60-watt incandescent lamp or one 15-watt fluorescent lamp for each 200 square feet of floor area. These lamps should be spaced 10 feet apart and installed 5 feet away from walls or solid partitions. The lights should be adjusted to illuminate the entire floor and roosting areas.

All-night lighting should provide just enough light to keep the hens "working" late in the evening and to start their day earlier. For night lighting, a 10- to 15-watt incandescent lamp is needed for each 200 square feet. This lamp should be placed above the feeding and watering area.

In both the egg-handling and the egg-cooling rooms, enough lights should be used to minimize shadow.

Outdoor lights and burglar alarms around poultry houses discourage thieves. These lights and alarms may be mounted on poles or on nearby buildings, and may be turned on or set from the dwelling or operated by automatic controls.

Where water-warming devices are used, one outlet is needed for each 400 square feet, or at least one outlet for each pen.

All wiring should be installed by qualified persons and should be checked periodically for safety.

To prevent severe slumps in egg production caused by light outage during power failure, a standby generator takes care of minimum requirements for lighting and pumping water for large flocks. The generator should be in a small building by itself. Local power companies can give advice regarding the equipment to select.

The approximate power requirements for various items of equipment are as follows:

Equipment:	*Horsepower*
Automatic poultry feeder	¼–¾
Portable elevator	½–1½
Platform hoist	½–1
Litter stirrer	¼–½

For small flocks, lanterns may be used for emergency lighting.

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